Oxford Tropical Handbooks

R. L. Fullerton

Building construction in warm climates

2

SECOND EDITION

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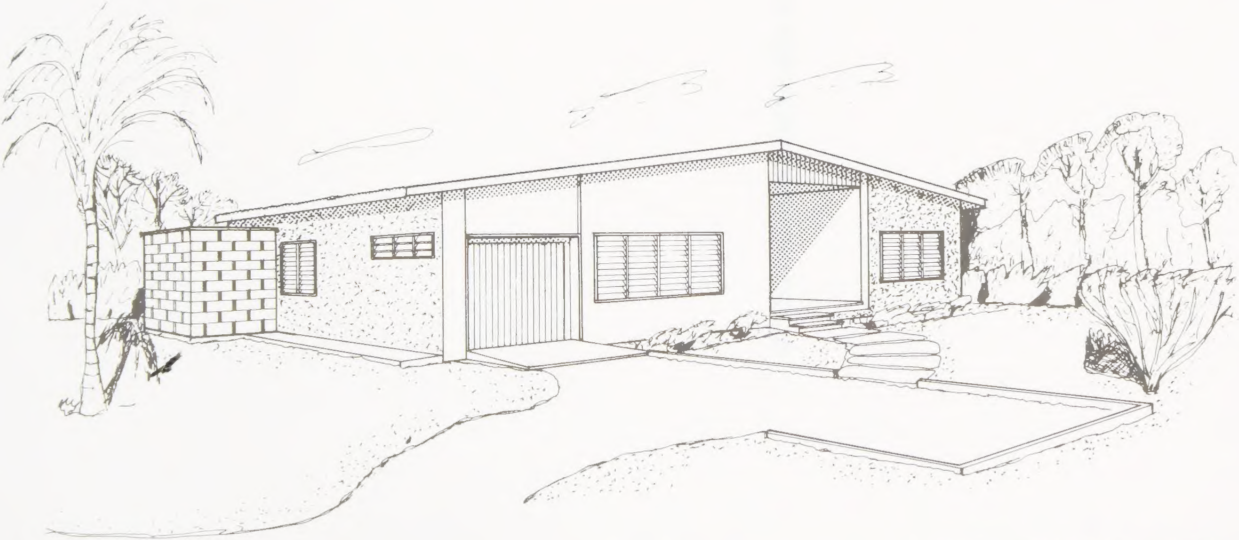
BUILDING CONSTRUCTION IN WARM CLIMATES

Volume Two



University staff bungalow

BUILDING CONSTRUCTION IN WARM CLIMATES

VOLUME TWO

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Contents

Abbreviations ix

Preface xi

Acknowledgements xiii

1. STAIRCASES 1

Introduction · Types · Setting out · Fire precautions · Finishings · Handrails and balustrades · Wood stairs · Concrete stairs · Formwork · Spiral stairs · Steel stairs

2. INTERNAL FINISHES 24

Plastering: Introduction · Materials · Lime · Portland cement · Building plasters · Sand · Lathing · Plasterboard · Plasticizers · Mixes · Key · Finishing coat

Ceramics, glass mosaics: Introduction · Glazed tiles · Decorative patterns · Ceramic mosaics · Adhesives · Marble · Mosaic · Glass

Internal joinery: Introduction · Doors · Interior room dividers · Internal joinery

Dry finishes: Introduction · Dry partitions · Wall linings · Movable partitions · Heat insulation · Cold storage · Suspended ceilings

Ironmongery: Introduction · Curtain tracks · Sun-blinds · Venetian blinds · Fixing of ironmongery · Door closers · Window-opening gear · Shutters and grilles

Painting: Introduction · Cost · Preparation · Colour · Protection · Mould · Food storage · Time · Types of paint · Special paints · Spread

3. SERVICES 70

Introduction

Ventilation: Natural ventilation: Air flow · Mechanical ventilation: Roof extractor units · Wall extractor units · Mechanical air control

Natural lighting: Introduction · Daylighting · Glare · Colour · Lighting needs

Artificial lighting: Introduction · Determination of illumination level · Glare · Incandescent lamps · Disadvantages of bulbs · Fluorescent tubes · Mercury vapour and sodium lamps

Electricity: Introduction · Electrical terms · Earthing · Cables · Electrical installation in a bungalow · Lighting circuits · Separate circuits · Safety precautions

Air-conditioning: Introduction · Principles · Distribution of air · Chilled water system · Packaged air-conditioning · Distribution of chilled water · Air cleaners · Humidifying

Refrigeration

Specialist services: Types of services · Ducting · Conduits and trenching · Location of Equipment · Lifts · Escalators

Food services: Type of equipment · Kitchen planning · Cleanliness · Ventilation

4. PLUMBING AND SANITATION 109

Introduction · Drainage · Soil-stacks · Sanitary ware: Water closets · Showers · Baths · Sinks · Wash-basins · Urinals · Drinking fountains · Cold water supply · Materials · Hot water supply · Rain-water disposal

5. MISCELLANEOUS WORKS 139

Introduction · Shoring · Underpinning · Scaffolding · Arch centering · Fencing · Drives and footpaths

6. MECHANICAL PLANT 159

Introduction · Cost · Maintenance · Manual labour · Factors affecting choice · Types of plant · Foundation equipment · Pumps · Self-powered tools · Transportation equipment · Compressed air and general plant · Welding plant · Concrete-making equipment · Block-making machines

7. SOIL AND SOIL STABILIZATION 175

Introduction · Methods of natural soil building · Soil stabilization · Testing soils · Soil-cement blocks · Preparation of soil · Cement · Mixing · Foundations · Bitumen blocks · Renderings · Soil-cement road and pavings · Sieving · Site preparation

8. PROJECT MANAGEMENT 185

Introduction · Drawing office · Research · Training Duties of a project manager · Pre-contract period · Staff · Materials · Plant · Sub-contractors and suppliers · Site agent · Contract drawings · Variations and claims · Records and progress · Programme and progress charts · Critical Path Method

9. DEVELOPMENTS IN BUILDING METHODS 198

Introduction · Shapes and their influence on building · Space structures · Grids · Grid domes · Prestressed concrete · Dome shells · Double curved roofs · Folded slabs · Industrial systems · Tall buildings

Guide to Further Reading 210

Glossary 211

Index 217

Quick-conversion chart at back of book

Abbreviations

Reference should also be made to Vols. 1 and 3.

°C	degrees Celsius
A	area; ampere
b.h.p.	brake horse power
B.R.E.	Building Research Establishment
B.S.	British Standard
B.Q.	bill of quantity
c/c	centre to centre
C.E.	consulting engineer
C.P.	Code of Practice
c.p.	chromium plated
C.P.M.	critical path method
C.S.U.	consumer supply unit
d.c.	direct current
dia.	diameter
D.O.E.	Department of the Environment
E.	east
ex	out of (timber)
F.S.	full size
H.D.	high density
h. & c.	hot and cold
k.d.	knock down
H.P.	hyperbolic paraboloid
kg/m^2	kilogram(mes) per square metre
*l*m	lumen
*l*x	lux = one *l*m/m^2
mm	millimetre
m^3/h	cubic metres per hour
m.s.	mild steel
m.c.b.	miniature contact breaker
N.	north
p.f.	push-fit
P.V.C.	polyvinyl chloride
P.C.	prime cost
P.S.	provisional sum
Q.S.	quantity surveyor
r.c.	reinforced concrete
r.w.g.	rain water gutter
S.	south
s.g.	salt glazed
S.S.	stainless steel
s.w.g.	standard wire gauge
t. & g.	tongued and grooved
V	volt
W	watt
W.	west
w.c.	water closet
μm	micrometre

Preface

This second edition of Volume 2 is now necessary because of the conversion from the imperial system of weights and measures to S.I.– the International System of units. The latter differs from the technical metric system in several respects, not the least being the absence of centimetres which were, of course, used for conversion in the first edition. Other changes will not be mentioned here as it is assumed that the reader has a background knowledge of SI and also of Dimensional Coordination.

Some conversion difficulties, however, still persist. Problems could arise for the builder should imperial and metric components get mixed up, a distinct possibility where old stock is held. Some materials, e.g. steel reinforcement, are now made in metric sizes. Many products, however, are still manufactured to imperial dimensions translated into metric, and care needs to be taken in these cases. For this reason the end-paper conversion charts have been retained. In this edition imperial fractions have been translated to the nearest millimetre.

Apart from metrication other changes will be noticed. Cross references to Volumes 1 and 3 have been freely made; all glossary terms can now be found in the index, which should provide for speedy location in the text; lettered captions, though still placed opposite illustrations for clarity, have been moved down to provide space for text in the interest of compactness and continuity. Sixteen pages of new and amended illustrations have been added, which include answers to questions in the text. As alternative answers are usually possible, there is still scope for exercise. Amendments to the original illustrations have also been made to bring them up to date.

R.L.F.

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- The Head of the Building Centre, Southampton and his staff, for their enthusiastic help and courtesy.
- Thorn Electrical Industries Ltd., for permission to reproduce Graph 1.
- Wadsworth Lifts Ltd., for permission to reproduce their Quick Reference Data (Table 2).

Considerable use has been made of catalogues of suppliers, builders' merchants, and manufacturers too numerous to mention here. The reader is, however, invited to get in touch with the Building Centre, Store Street, London WC1E 7BT, for information on most of the products mentioned herein.

Extracts from the following British Standards are reproduced by permission of the BSI, 101 Pentonville Road, London N1 9ND, from whom complete copies can be obtained:

B.S. 565: 1972	Glossary of terms relating to timber and woodwork.
B.S. 1584: 1949	Glossary of terms used in refrigeration.
B.S. 2015: 1965	Glossary of paint terms.
B.S.3589: 1963	Glossary of general building terms.
B.S. 3660: 1976	Glossary of terms used in the wrought aluminium industry.
B.S. 4727: Parts 1 and 4	Glossary of power, telecommunications, electronics, lighting, and colour terms.

1 | Staircases

1.1 Introduction

The term 'staircase' originally referred to the space or case in which the stairs were built. The terms 'stairs' and 'staircase' are now used indiscriminately, although the latter is still used to describe the enclosure, often with glass walls or open screens in modern buildings, which houses the stairs. Generally speaking, a 'stairs' is a series of steps connecting two floor levels, while a 'flight' is a series of steps between landings or platforms. See Glossary for further definition.

1.2 Types of stairs

These are very numerous; some are given here but further examples have been added in Volume 3, Chapter 9. Only straightforward types of stairs of the kind suitable for erection in developing countries with warm climates have been chosen for illustration. Elaborate joinery methods involving complex woodworking machinery have been omitted, though some imported models are shown in Volume 3.

Ramps are inclined surfaces for foot or vehicular traffic. Foot ramps are used in crowded places — stadiums, railway stations, etc., where steps could be dangerous. They are also used as approaches to bridges or to tunnels crossing busy roads or railways, particularly where bicycles, perambulators, hand carts, or trolleys require access. Pedestrians carrying head loads prefer them to stairs.

Ramps for foot traffic should not exceed a slope of 1 in 8, and 1 in 10 is preferable. If it is necessary to exceed this then a handrail should be provided. Ramps can be expensive and take up more space than stairs, so should only be constructed when necessary. Spiral or curved ramps are sometimes used instead of straight ones. Although costly they are often more convenient, take up less space, and are quite pleasing in appearance. To prevent slipping, the surface of the ramps should be treated by the use of carborundum and/or grooves or indents formed in the surface finish.

During the construction of tropical buildings, ramps are widely used in scaffolding instead of ladders, especially where hand labour is employed, Fig. 5.17.

Types of stairs

Fig. 1.1. Stone steps
- *A* 300 mm × 150 mm approx. stone steps
- *B* Random stone walling
- *C* Gravel or stone paving

Fig. 1.2 Open tread straight flight stairs
- *A* 300 mm × 38 mm hardwood treads (*see* Fig. 1.10)
- *B* 300 mm × 38 mm close string
- *C* Tiles (P.V.C. or vitreous) or concrete slab
- *D* Flush skirting

Fig. 1.3 Concrete steps with timber tread (*see also* Fig. 1.12)
- *A* 300 mm × 32 mm hardwood tread
- *B* 32 mm × 32 mm dovetail bearer
- *C* Reinforced concrete stairs

Fig. 1.4 Reinforced concrete cantilever steps
- *A* R.C. precast steps (*see* Fig. 1.11)
- *B* Solid concrete block or brick wall

Fig. 1.5 Reinforced concrete spine and cantilever staircase
- *A* R.C. spine cast *in situ*
- *B* R.C. precast setps
- *C* R.C. beam to suit span
- *D* R.C. precast top tread

Fig. 1.6 R.C. staircase cast *in situ*
- *A* R.C. wall
- *B* R.C. cantilever stairs
- *C* R.C. landing
- *D* Metal balustrade and handrail

Fig. 1.7 Spiral staircase
- *A* Precast concrete steps
- *B* Central column with r.c. filling
- *C* Top landing

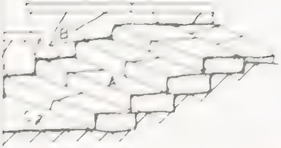


Fig 1.1

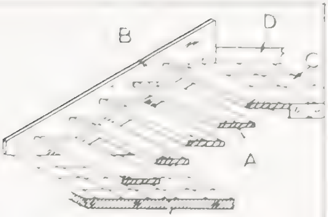


Fig 1.2

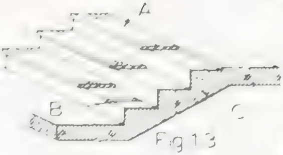
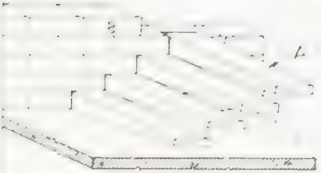


Fig 1.3



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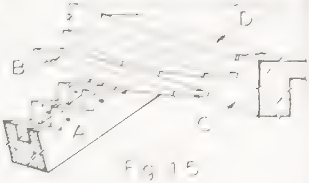


Fig 1.5

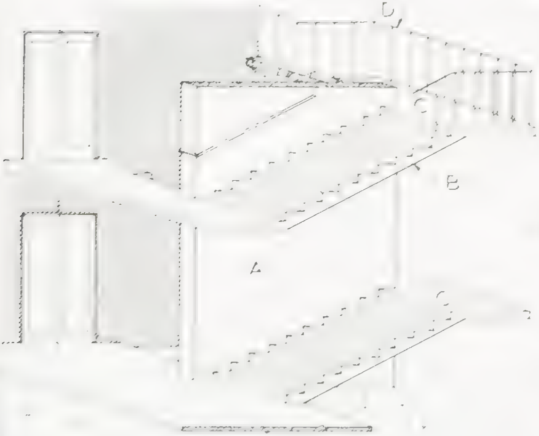


Fig. 1.6

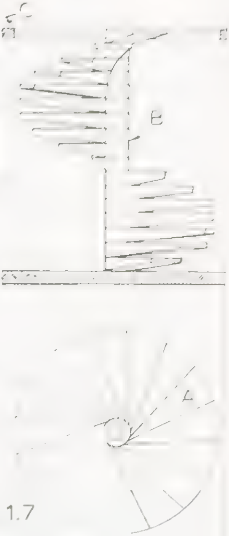


Fig. 1.7

TYPES OF STAIRS

1.3 Setting out of stairs

When designing stairs there are certain empirical rules, i.e. rules based on experience, which should be observed. These are mainly concerned with obtaining a suitable size of tread or going (G) in relation to the riser (R), in order that steps may be mounted comfortably. The most common rule is:

Going plus twice the riser = 610 mm approx. (but see Vol. 3). Thus a 230 × 190 mm step gives:

$$230 + 380 = 610 \text{ mm.}$$

A less popular rule is the *Centimeter rule* where:

$$\text{going times riser} = 445 \text{ cm approx.}$$

Applying this rule to the usual step sizes we get

$$\begin{aligned} G \times R &= 425 \text{ to } 465 \text{ cm} \\ 30 \times 14{\cdot}5 &= 435 \\ 23 \times 19 &= 437 \\ 28 \times 16{\cdot}5 &= 462 \\ 30 \times 15 &= 450 \end{aligned}$$

The *going* should not be less than 220 mm. In public buildings a stair with a going of 280 mm and a riser of 165 mm would be satisfactory. A domestic stair could have a 230 mm going and a riser of 190 mm; but maximum and minimum sizes, pitch, etc. are described in Volume 3. Basement-, attic-, or back-stairs frequently have 220 mm treads and risers if by-laws permit.

Nosings. These are usual in the case of precast concrete, stone, or wood stairs. They are also found where the tread is added after construction *in situ*. The object is to provide a wider tread without an increase in overall length, Fig. 1.12. Concrete stairs frequently have sloping risers which give the same result, as in C, Fig. 1.12.

Flights or stairs between landings should not be too long, otherwise climbing becomes tedious. Model regulations lay down 15 or 16 risers per flights as a maximum (and not less than two).

Landings should also have limiting dimensions. Some by-laws require a landing to be not shorter in direction of travel than the width of the stairs. A good rule is to make the landing longer than this by at least the width of one tread, Fig. 1.6.

Headroom can sometimes be a problem in stair design. The minimum height under most by-laws is 2 m measured vertically from the line of the pitch. This can often affect the size of the step.

The normal width for a domestic stair is 850 mm to 1 m.

Handrails for private stairs are usually 840 mm to 900 mm high and 1·1 m for common stairs. If the stairs are wider than 1 m, then handrails should be fixed on both sides.

1.4 Fire precautions

Fire regulations can be very strict in some countries, especially for public staircases used by a great many people. In the event of fire, the staircase has to be used as a means of escape, but unfortunately it can also act as an opening through which the fire can travel from one floor to the next. Construction varies, but many of the rules and suggestions given in **1.3** on setting out cover normal requirements.

The term 'fire escape' means an escape route by exits such as corridors, stairs, etc., leading direct to the ground or an open space. The means of escape has to be enclosed by a *fire-resisting construction*, i.e. brick or masonry walls of adequate thickness. It has also to be provided with fire-resisting doors placed so as to prevent the spread of smoke or fire. Normally the stairs are built on to an outside wall.

Fire regulations vary from one country to another, but there are some general rules. For buildings under about 12 m high (which a fire ladder can reach), a staircase with one self-closing, fire-resisting door with access to a roof is enough. This roof should connect to an adjoining building. There should be one such staircase every 20 m. No fire precautions are necessary for buildings under 6 m high.

Open balconies of the type common in tropical countries are a useful means of escape if they are made of fire-resisting material. Such balconies also provide for a quick dispersal of smoke. They must, however, adjoin a street or open space.

Walls to fire-resisting staircases and lobbies must be at least 200 mm thick. The design of these lobbies plays an important part in the overall plan of the building. Further information on fire precautions is given in Volume 3, Chapter 14.

Exercise 1.1. The reader is advised at this stage to obtain a copy of his local by-laws and write up, as an exercise, brief notes on fire regulations for buildings between 6 m and 12 m high, pertaining to staircases in public buildings in his own area. Sketches should be included as necessary.

1.5 Finishings

Surface finishing to steps may be done in several ways. It can be

Continued on page 10

Reinforced concrete and timber steps

Fig. 1.8 Stone or concrete steps
A Concrete base
B 300 mm × 150 mm steps

Fig. 1.9 R.C. precast cantilever steps
A R.C. spandrel steps
B 12 mm m.s. reinforcement
C 6 mm distr. bars at 300 mm c/c
D Alternative type of joint

Fig. 1.10 Open-tread timber staircase
A 300 mm × 50 mm hardwood treads
B 280 mm × 50 mm strings housed to newel
C 100 mm × 100 mm newel
D Nosing to match tread
E 64 mm trimmer (depth to suit floor)
F 150 mm × 25 mm baluster rail
G 28 mm dia. balusters at 1 m c/c

Fig. 1.11 Precast cantilever r.c. steps
A Plan of step
B 12 mm m.s. rods
C 10 mm ties
D 12 mm collar
E 16 mm baluster bolted to every step

Fig. 1.12 Types of precast finishings to concrete steps
A 50 mm terrazzo paving
B 50 mm precast granolithic or terrazzo
C 38 mm marble tread with 12 mm riser to match
D 19 mm × 150 mm grooved quarry tile nosing
E Floor finish (*see* Floors)

Fig. 1.13 Open-tread timber staircase
A 300 mm × 38 mm hardwood tread dowelled to string
B 300 mm × 64 mm hardwood open string
C 16 mm dia. bolt and plate supports
D 75 mm trimmer: depth to suit span

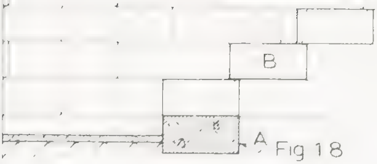


Fig 1.8

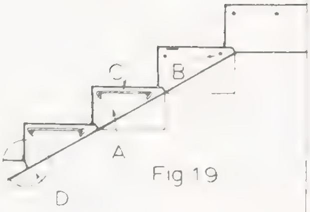


Fig 1.9

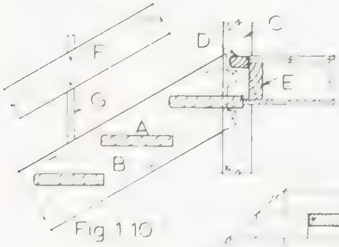
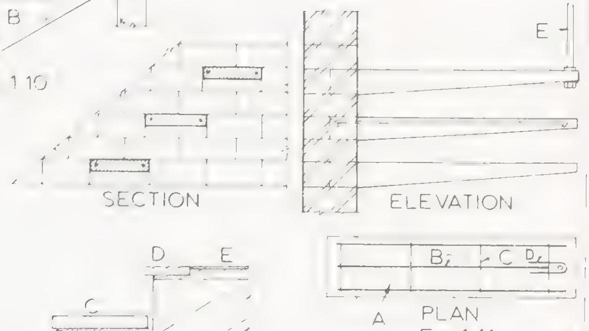


Fig 1.10



SECTION

ELEVATION

PLAN

Fig. 1.11

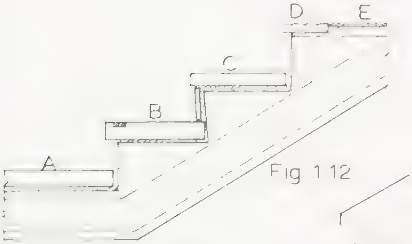


Fig 1.12

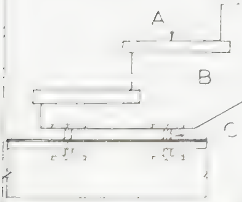
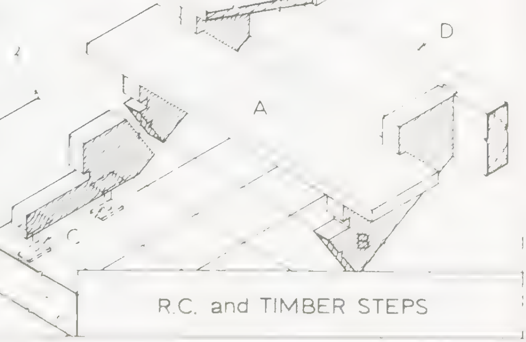


Fig 1.13



R.C. and TIMBER STEPS

Single flight open-tread stairs

Fig. 1.14 Isometric view of open-tread timber stairs
A External wall of 225 mm brick or block
B 280 mm × 32 mm treads to lower steps
C 280 mm × 38 mm stair treads
D 280 mm × 38 mm strings
E 250 mm × 63 mm wrot trimmer joist
F 250 mm × 75 mm wrot trimming joist
G 250 mm × 50 mm joists
H 50 mm × 25 mm nosing
J 20 mm dia. m.s. newel
K 12 mm dia. m.s. balusters
L and *M* 38 mm × 10 mm m.s. core welded to baluster
N 64 mm × 45 mm rounded handrail
O 12 mm tension rods

Fig. 1.15 Section through trimming joist
P 12 mm m.s. balusters bolted to trimming joist

Fig. 1.16 Front view of outer string
D 280 mm × 38 mm outer string
L 38 mm × 12 mm m.s. core welded to baluster
F 250 mm × 75 mm trimming joist

Fig. 1.17 Isometric view of outer string and trimmers
D Outer string
L M.S. core
J Newel welded to core and bolted to trimmer
K Balusters

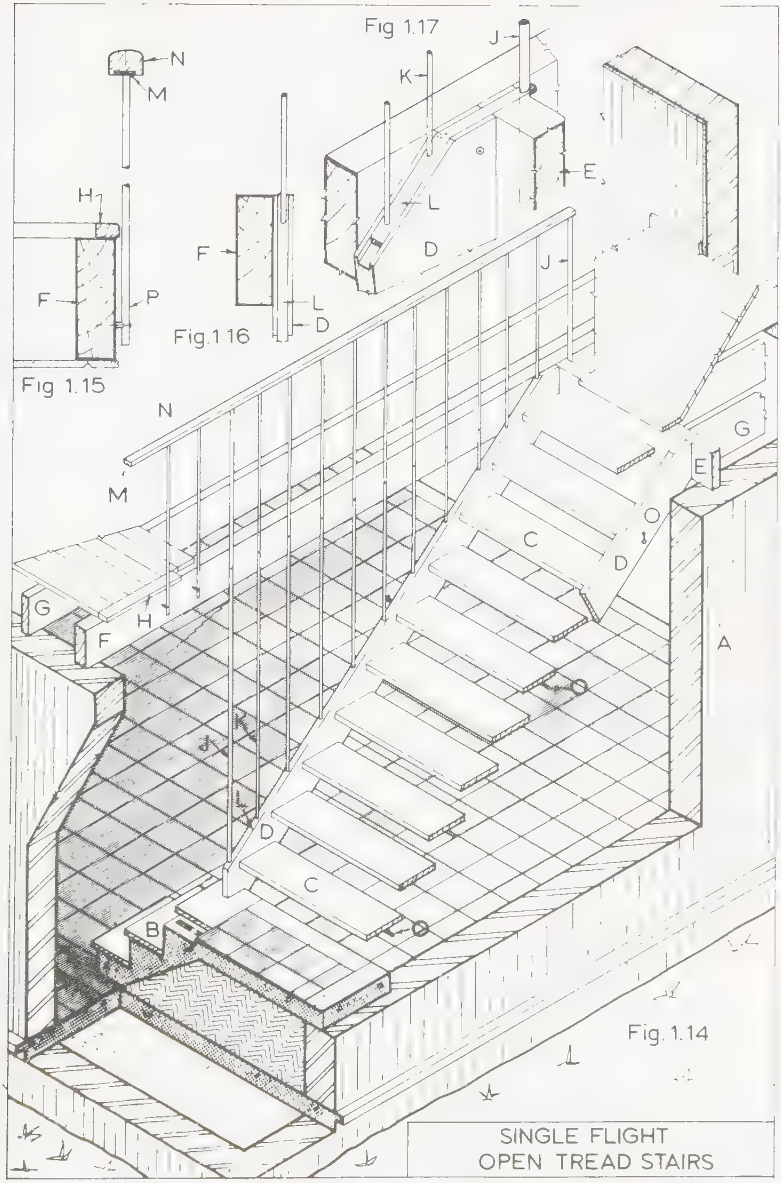


Fig 1.15

Fig.1.16

Fig 1.17

Fig. 1.14

SINGLE FLIGHT
OPEN TREAD STAIRS

incorporated into precast concrete stairs during manufacture (cast stone) or the rendering applied to concrete or masonry stairs after fixing. The most common finishings of this type are granolithic and terrazzo. Often precast slabs of these materials are applied to treads and risers after the stairs have been constructed *in situ*. Hardwood treads are also popular where timber is available. They may consist of a 32 mm board secured to dovetail bearers set in the step, as in *B*, Fig. 1.3, or battens slatted to provide a grip and prevent warping. The latter are good for bare feet or sandals but tend to harbour lizards, litter, etc. and are difficult to clean out.

Non-slip finish is provided in a number of ways; carborundum sprinkled into granolithic is the cheapest and most popular. Terrazzo treads often have a groove cast in them which is then filled with an abrasive paste of carborundum and cement, as in *B*, Fig. 1.12. Non-slip proprietary strips of various materials can also be inserted.

Clay vitreous tiles grooved and bedded in cement are also popular, as in *D*, Fig. 1.12, although they need to be firmly bedded with an epoxide resin cement for preference (see Plastics).

Linoleum or P.V.C. tiles protected by a metal nose-strip are also used. Many other types of nosing are available, some of which are shown in Volume 3 and in *Specification* (see Guide to further reading).

Single flight open-tread stairs

Fig. 1.18 Plan of open-tread timber stairs
Q Dwarf wall supporting lower landing
R R.C. lower landing
D Outer string

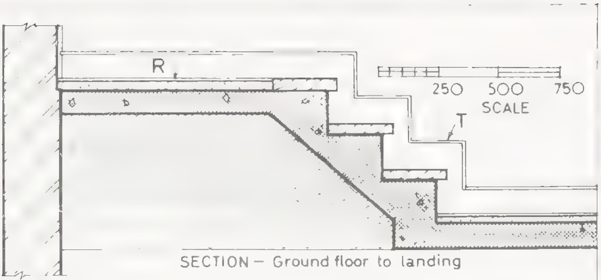
Fig. 1.19 Vertical section through stair
S Ceiling line

Fig. 1.20 Section through lower landing and steps
T Flush skirting groove
R Quarter-space landing

Fig. 1.21 Sketch showing housing of tread to string

Fig. 1.22 Section of tread
A = 225 mm
B = 196 mm
C = 280 mm

Fig. 1.20



SECTION — Ground floor to landing

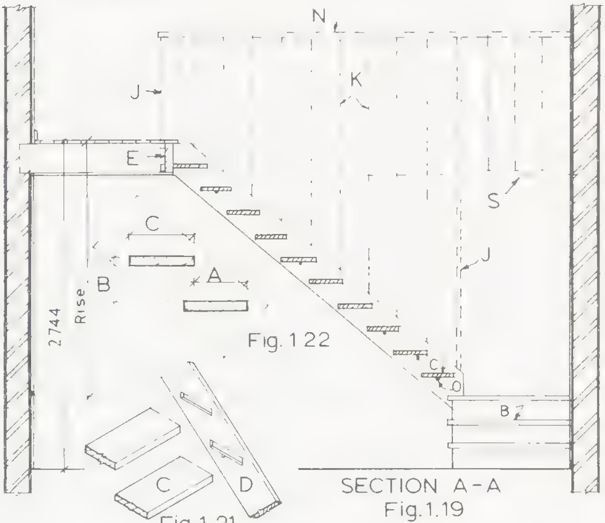
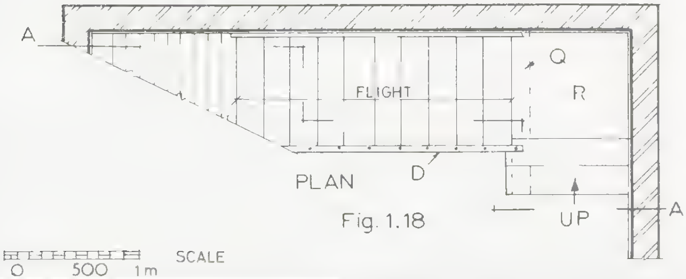


Fig. 1.22

SECTION A-A
Fig. 1.19

Fig. 1.21



PLAN

Fig. 1.18

SINGLE FLIGHT OPEN TREAD STAIRS

1.6 Handrails and balustrades

Balustrades may be of various designs. The most popular today are usually the simplest both in design and construction. Open balustrades are usual in warm countries as they allow better air circulation. These balustrades in a simple form often consist of 20 mm m.s. rods set in concrete, or bolted to wood or metal treads, Figs. 1.10, 11, 27, 39, etc. A simple but effective type of balustrade for a domestic house is shown in Fig. 1.15, and consists of an m.s. rod welded to a core 38 × 10 mm top and bottom. The handrail is secured by screwing upward through the core, which is drilled and countersunk for the purpose. Many other types are available.

Solid balustrading of timber, plywood, plate glass, metal, or concrete may also be used. The last named can be seen in section at the landing balustrade, Fig. 1.23. The reinforcement bonding to the stair balustrade is similar. Other designs are shown in Volume 3. Generally, the open type of balustrade is preferred, except when protection against driving rain and wind is needed.

Handrail designs are usually kept simple. This is necessary where craftsmen cannot always be trained to give a high-class finish involving ramped or wreathed work at turns in the stairs. Timber, too, unless carefully selected and seasoned, is liable to twist or shrink. For this reason the handrail is frequently stopped at the end of a flight instead of being made to turn the corner. Although not as attractive a finish as that of a continuous handrail it has many advantages, including ease of execution.

Where curved or continuous handrails are necessary, e.g. spiral staircases, a plastic-covered core is often used. This consists of a cellulose acetate material, or P.V.C., etc., moulded over a soft iron core shaped to suit the stairs and welded to the baluster. Plastic handrails are smooth and neat and can be obtained in a variety of colours. See *Specification* and Volume 3 for further details.

1.7 Wood stairs

A number of types of wood stairs are in use today, ranging from the simple ladder to bifurcated (forked) helical or geometrical stairs of intricate design. Only straight flights with *open risers* will be dealt with here as these are the most popular and economical, but further examples are given in Volume 3.

The section illustrated in Figs. 1.2 and 1.10 shows the simple ladder type with open risers. One string in Fig. 1.2 has been omitted for clarity. In Fig. 1.10 the strings *B* are shown housed to newel posts. The top trimmers *E* have an exposed face when acting as a riser. The bottom of the string may be bolted to the wood-joisted floor or secured to a concrete floor by means of an m.s. angle cleat bolted to the side of the string and let into the floor.

A more elaborate type of open riser is shown in Fig. 1.13. Cut or open strings *B* are notched to receive the tread and riser, the treads being cantilevered from 150 mm to 230 mm for a 1200 mm to 1350 mm stairs. Apart from enhancing the appearance and providing a simple means of securing the balustrade, it also reduces sagging of the tread by shortening the span. If preferred, instead of the dovetailed housing to the trimmer, an m.s. 80 × 80 mm angle cleat may be screwed to the trimmer and side of the strings. This gives a positive fastening and is not likely to fail through shrinkage. Such a staircase can also be anchored to an r.c. landing by omitting the trimmer and bolting an m.s. angle plate to the top of each string and building this into the edge of the r.c. landing.

Exercise 1.2. The stairs detailed in Fig. 1.13 finishes on to an r.c. landing. Show the construction at this level together with a suitable floor finish.

A simple straight flight of open-riser stairs is shown in Figs. 1.14 to 1.22. The treads *C* are housed to the strings as shown, and the strings bound together with 12 mm m.s. rods *O* placed under approximately every other tread. These are threaded at either end and fitted with nuts and washers for tightening. The bottom of the outer string may be housed into the end of the top tread of the lower flight, and the inner string housed to the edging strip of the landing. The top inner string is simply coach-bolted through the trimmer *E* or plugged to the wall.

Other types of wood stairs are in use, frequently with solid risers and wood balusters (see Volume 3). These are not as widely used in the tropics as they used to be, the prevailing fashion of open risers being more suited to the climate. Open risers permit free air circulation, and give more light and a greater sense of spaciousness. They are also more easily constructed where skilled joiners and woodworking machinery are not readily available. This can be quite important and affects stair construction considerably.

1.8 Concrete stairs

Reinforced concrete staircases are used in many types of building today. They can be designed to be as strong as necessary, are fire-resistant, and once the mould is made, can be cast in geometrical or irregular shapes without difficulty. The whole staircase can be cast *in situ* as in Fig. 1.6, or individual steps precast and placed in position as in Fig. 1.4. Where heavy lifting tackle is available, whole flights may be precast and lifted into position to form a prefabricated stair (see Volume 3). This is usual, however, only in multi-storey buildings or where many identical flights of stairs are needed.

Many types of r.c. stairs can be made. A few are shown in Figs. 1.3 to 1.7 and in Volume 3. The simple type of step shown in Fig. 1.3 is usually built to connect floors at two levels. In this case the treads are finished in wood or stone, the latter sometimes broken and laid as crazy paving. Reinforcement can be added to the stairs if there is a likelihood of subsidence.

Precast concrete steps take a number of forms, (Figs. 1.4, 1.5 and 1.7 to 1.11). Figure 1.11 shows a popular type of cantilever step which can be built into a brick or block wall. It is desirable, however, that the height of the block coincides with the riser of the step. Figure 1.9 shows an older type of precast step, the spandril shape, which has a square seating for building into the wall. This design was once popular for stone steps and is still used where stone is plentiful. A 150 mm deep step can extend to a width of about 1 metre unsupported; it is sometimes termed a 'hanging step'. The rabbet at the junction of the tread and riser helps to resist thrust and vertical movement.

A popular type of stairs for public places, schools of two storeys, etc., is shown in Fig. 1.5 and detailed in Figs. 1.24 to 1.29. The central spine is usually cast *in situ* with the top edge stepped as shown. The steps in this case are precast with a terrazzo finish, bolted to the spine, and grouted in firmly. Balusters are fixed as shown in Fig. 1.11. Typical reinforcement is shown, though this would need to be calculated to suit individual requirements. The intermediate landing has a flat terrazzo slab and the top landing has a flat slab built in. The small portion of the stepped spine where it shows beneath the tread can be painted to match the staircase finish.

A common type of external r.c. staircase which is independent of other support, except at landings, is shown in Fig. 1.6 and detailed in Fig. 1.23. In this case the central wall supporting the cantilevered stair is reinforced (omitted here for clarity) and the bars from the wall bent to support the steps. Only sufficient steel has been shown to make the general principle clear. A conventional method of indicating steel rods has been adopted with standard abbreviations used for identifying or *calling up* reinforcement. These are:

R.C. staircase

Fig. 1.23 Working drawing of r.c. staircase

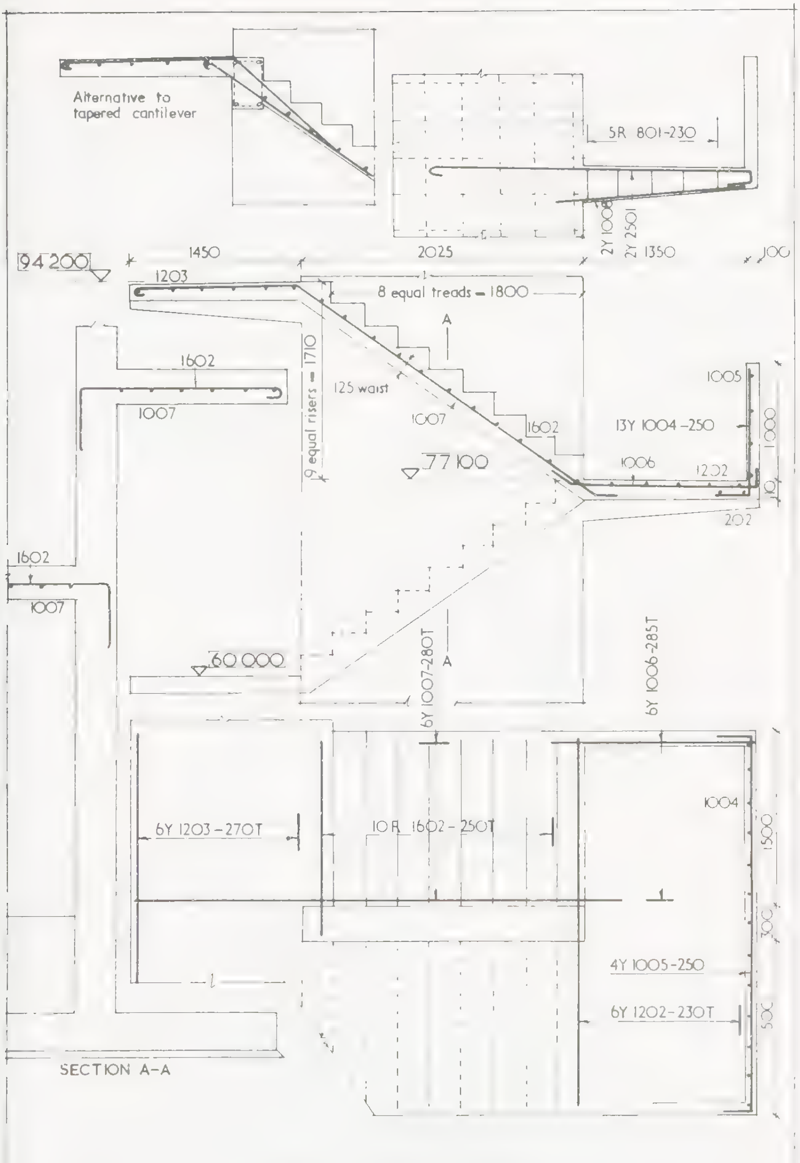


FIG 1.23 REINFORCED CONCRETE STAIRCASE

R mild steel round bars
Y high tensile round and square twisted square bars
B bottom face of slab or beam
T top face of slab or beam

There are also other abbreviations and symbols used by the structural engineer.

Bars are usually called up in the order of: number of bars, type of steel, diameter of bar, bar mark, spacing, and position in slab. Thus in Fig. 1.23 the landing steel shown on the plan as 6Y 1202 – 230T refers to six high-tensile steel bars of 12 mm diameter, bar mark 02, at 230 mm centres placed at top of slab. Spacing of reinforcement is often given in 25 mm increments (50 mm over 200 mm), though this is not always done.

The landings are supported by tapered cantilevers reinforced as shown, but the roof canopy is held by an r.c. beam. Where landings are subject to tropical rain they should be finished to a slope of 1 in 25 and spouts provided, (see Vol. 1).

R.C. spine and cantilever staircase

Fig. 1.24 R.C. spine and cantilever staircase
A Lower landing
B Middle landing
C Top landing
D Precast cantilever step
E R.C. spine cast *in situ*

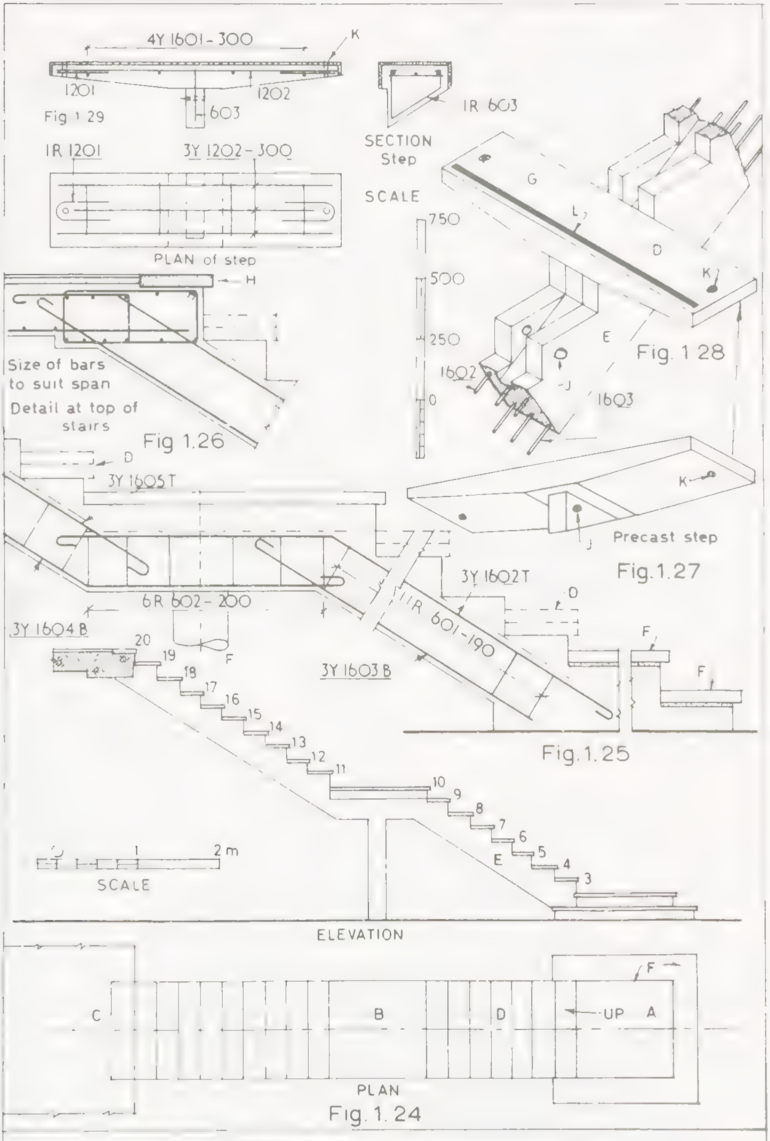
Fig. 1.25 Detail of reinforcement—bottom flight and landing
F Terrazzo paving slabs
D Terrazzo finished precast step

Fig. 1.26 Detail of top landing and beam
H Built-in terrazzo slab (reinforcement to suit span of landing)

Fig. 1.27 Sketch of precast step
J 25 mm hole countersunk for bolt
K Hole for balustrade (*see* Fig. 1.11)

Fig. 1.28 Sketch of spine and precast step
L Non-slip carborundum or similar inset

Fig. 1.29 Plan and sections of step



R.C. SPINE and CANTILEVER STAIRCASE

1.9 Formwork to stairs

The customary type of formwork for stairs cast *in situ* is shown in Figs. 1.37 and 1.38. The inner string *A* is nailed to the wall, plugged if necessary, and given a 50 mm clearance above the tread. Cleats *B* are then nailed to the string, vertical or sloping as required, to support the riser board. The outer string *C* may be cut to the shape of the steps and the riser nailed to it. It could, however, be constructed as the inner string but made deeper to support the end of stair, *D*. For steps over 1 metre wide a centre brace *E* is necessary to prevent bulging. This is shown held down by tying wire *F* looped over the brace, passed through the soffit and tightened. Sometimes the cleat is omitted.

The soffit boards may be placed either longitudinally or horizontally. The latter method is shown here, Fig. 1.37, which enables shorter boards to be used and helps to reduce warping. When using hardwood a support is not usually needed under the outer string. Extra props are always advisable, however, when concrete is being poured. Extendible steel props are excellent for this purpose.

The strutting and propping *H* is sometimes done with timbers of square section. This enables them to be used either as props or bearers and prevents the possibility of bearers being laid on the flat instead of on edge. The steel reinforcement of 12 mm bars, shown at *J*, Fig. 1.37 is a fairly typical arrangement. The bottom steel *K* of the landing would come from the next flight if a quarter space landing were used.

1.10 Spiral stairs

This type of stairs has been in use for centuries. Many ancient examples

R.C. spiral staircases

Fig. 1.30	Plan and vertical section
Fig. 1.31	Plan of reinforcement to base
Fig. 1.32	Reinforcement to shaft
Fig. 1.33	Plan of precast step with bottom reinforcement
Fig. 1.34	Plan of precast step with top reinforcement
Fig. 1.35	Section through precast step and landing
Fig. 1.36	Plan of column reinforcement to landing

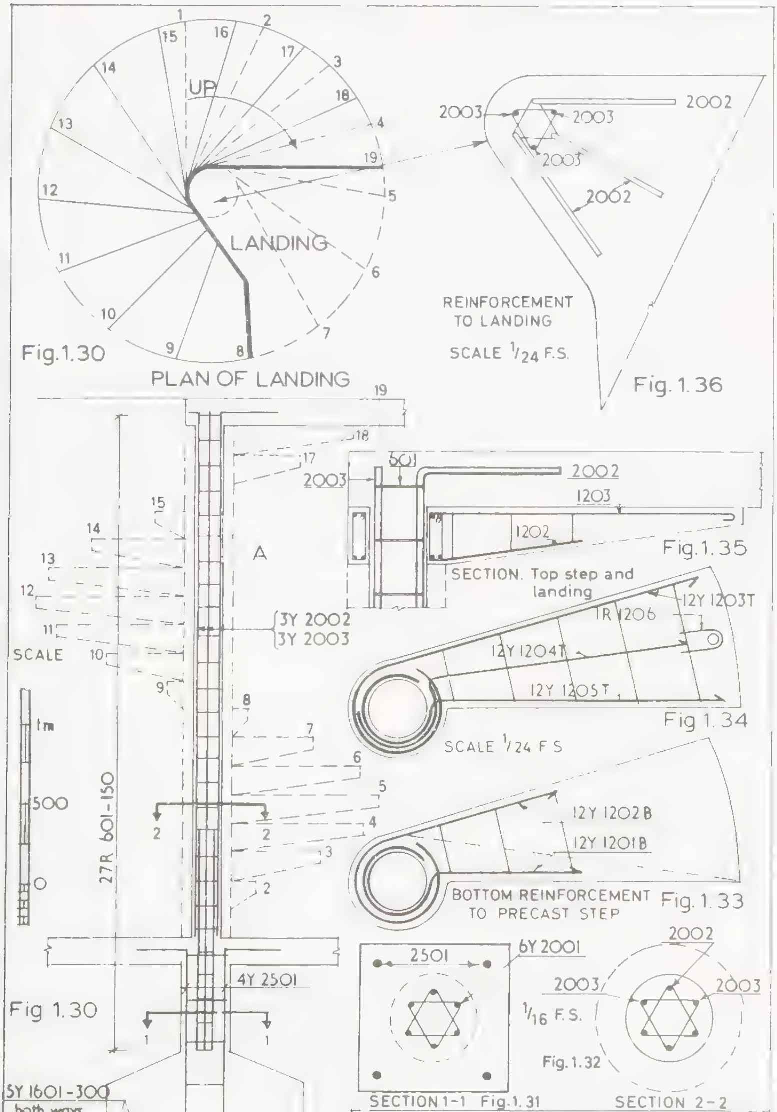


Fig.1.30 PLAN OF LANDING

Fig. 1.36

Fig.1.35 SECTION. Top step and landing

Fig 1.34

Fig. 1.33 BOTTOM REINFORCEMENT TO PRECAST STEP

Fig 1.30

SECTION 1-1 Fig.1.31

Fig.1.32 SECTION 2-2

R.C. SPIRAL STAIRCASE

enclosed in round towers are still in use today. During recent years they have come back into favour, often in a modern form. They can be constructed of solid stone, r.c., or metal. They take up little space and are frequently built as independent units. Figure 1.7 shows a general arrangement and r.c. details with precast steps are given in Fig. 1.30. Each step is identical and cast with a hollow cylinder at one end to take a cage of reinforcement *A*. This is lowered in after the steps are in place and concrete poured to make a solid column. The top of the column is anchored to the landing as in Fig. 1.36. The spiral baluster is fixed either as shown in Fig. 1.11 or by inserting two holes in one step. The baluster can then pass vertically through two steps giving extra support to the cantilever if required. Figure 1.39 shows this arrangement in metal. Further examples are given in Volume 3.

When setting out spiral stairs care must be taken to allow a minimum tread width of 250 mm at a distance of 450 mm from the column and to ensure that the headroom at all times is not less than 2 metres. Where there is no reason for the position of the bottom or top steps to be fixed to any alignment the question of headroom is simplified. One advantage of precast steps is that there are no internal stresses which could give rise to racking.

Exercise 1.3. Give the working details for the lower flight of the reinforced concrete stairs shown in Fig. 1.23.

1.11 Steel stairs

These have many advantages over wood or concrete. They are light and neat in appearance, especially in short flights. They can be quickly fabricated and easily erected complete with steel balusters and handrails. They are also termite-proof. Pressed-steel stairs can be expensive if they have to be imported. *Spiral* steel stairs, however, are fairly easy to make up locally, where light metal sections and welding plant are available, Fig. 1.39. Steel spiral stairs, although excellent as features in confined spaces or where a second staircase is needed, are not

Concrete formwork. Steel spiral stairs

Fig. 1.37 Sketch of formwork to stairs showing reinforcement

Fig. 1.38 Section through r.c. stairs

Fig. 1.39 Plan of treads to spiral stairs

Fig. 1.40 Baluster details to step

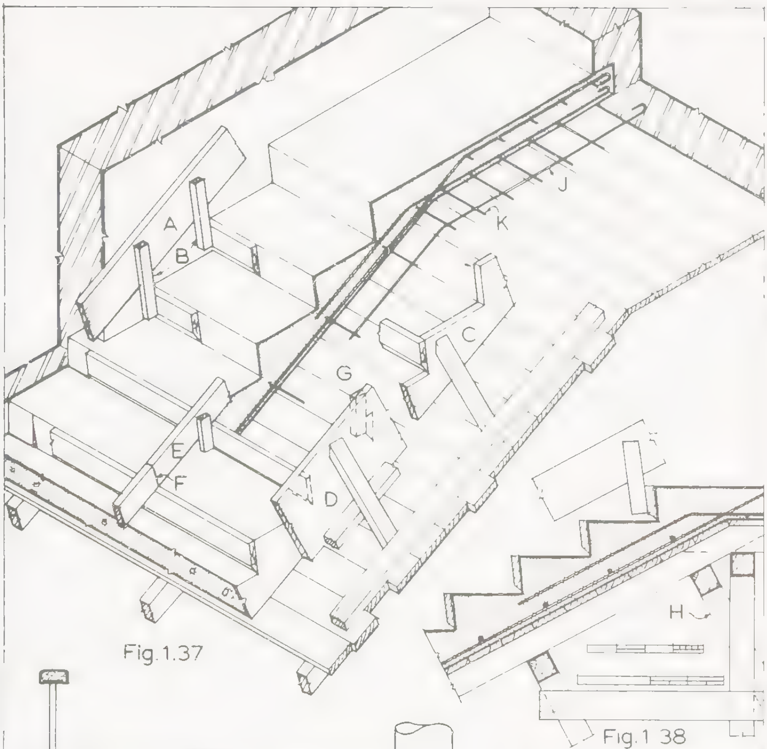


Fig. 1.37

Fig. 1 38

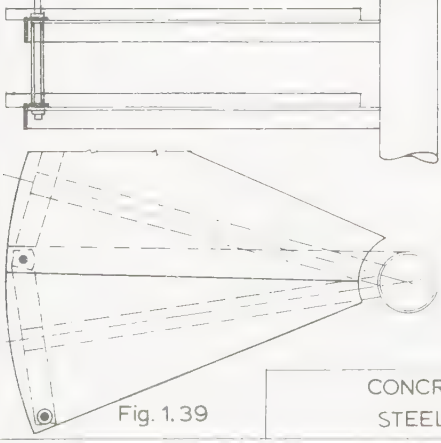


Fig. 1.39

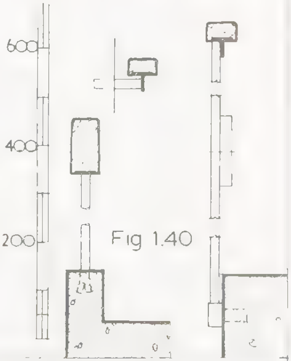


Fig 1.40

CONCRETE FORMWORK-
STEEL SPIRAL STAIRS

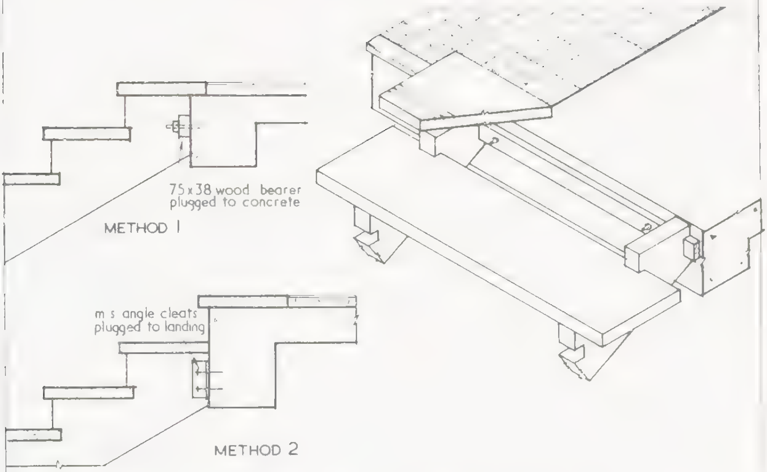
favoured for general use as they lack stability and are difficult to use in busy situations. To assist stability, the balusters should always be connected to two treads as shown.

A simple low-cost, straight-flight stairs can be made up by using 'Dexion open plan' as treads and Dexion angles as strings. These can be built up by semi-skilled labour quite quickly. They are termite- and rust-proof and useful externally in wet climates.

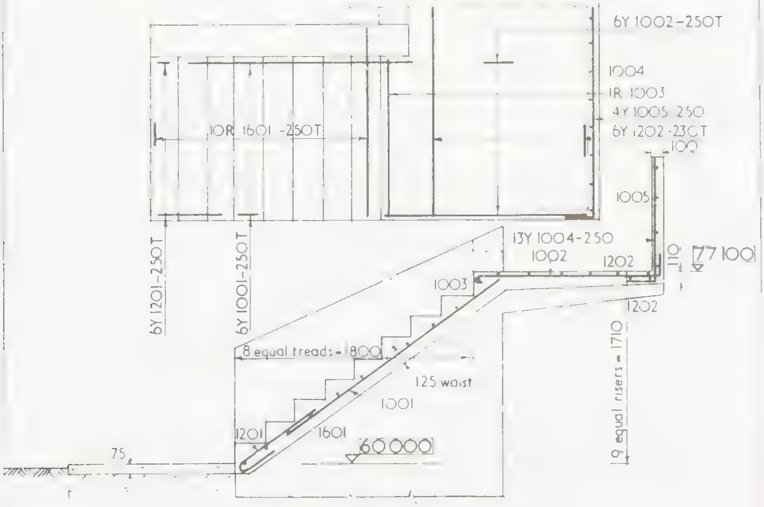
Cast iron stairs are still used in the tropics, but not to a great extent, largely because of the expense of importing treads which are heavy and costly in transport.

Fire escapes and cat-walks in steel are shown in Volume 3.

Steel ladders are often used for access to roofs, water tanks, and towers and also as emergency stairs. For details of pitch, clearances, handrails, and other requirements the reader is advised to consult his by-laws, where these exist, but see Volume 3. Generally there are three types of ladder: the *step* ladder, usually with 100 mm treads, the *rung* type ladder with 20 mm steel rungs, and the simple *U-shaped rung* ladder with the ends built into the wall. In the last case no strings are needed.


75 x 38 wood bearer plugged to concrete
METHOD 1
m s angle cleats plugged to landing
METHOD 2

ANS. – EXERCISE 1·2 WOOD STAIRS TO CONCRETE LANDING



ANS. – EXERCISE 1·3 REINFORCED CONCRETE STAIRS. DETAIL SHEET

2 | Internal Finishes

PLASTERING

2.1 Introduction

The art of plastering varies greatly from one country to another. This is due to a number of factors: traditional customs, religious influences, the materials available, the tools used, and the background to which it is applied. Only the main plastering techniques will be dealt with here, including those most common to tropical countries.

2.2 Materials

The chief materials used for plastering are lime, Portland cement, gypsum plasters, and sand. Other materials, e.g. pozzolana, are used locally, sometimes over wide areas, but are not universal and so will not be discussed here.

LIME Lime for plastering is produced by calcining (burning) calcium carbonate (as limestone, usually chalk-stone) which removes the carbon dioxide. Lime resulting as a by-product from acetylene manufacture is also used for plastering. On cooling, the quicklime is stored in a dry place from where it is transported to its destination. Before it can be used, however, the lime must be 'slaked', i.e. water added, a week or two before it is needed. Lime for plastering is usually 'fat' lime, i.e. easily slaked and workable as distinct from *hydraulic* lime which is not, but which has the property of setting under water. Lime burnt locally under primitive conditions is rarely of good quality, and results in pitting or blowing of the rendering caused by impurities and uneven burning.

Modern lime production can be carried out on similar lines to the manufacture of Portland cement. Quicklime is exposed to steam, which reduces the lime to powder. This is bagged for transport in the same way as Portland cement, although it is only about half its weight. The lime is usually soaked on site for a short while, say, a day, after which it is ready for use.

PORTLAND CEMENT Brief notes on manufacture may be found in

Concrete, Volume 1. Where a country has no supply of its own, cement may be imported in 50 kg bags or drums, as described in Volume 1. There appears to be no reason, however, why the clinker produced by burning, when cooled off, should not be shipped to its destination where it could then be ground into cement. This method would have a number of advantages. It would be cheaper to transport in bulk, it could be freshly ground as required, and the clinker would be unaffected by moisture, which is an important consideration in humid areas. The grinding process could be incorporated into the full production plant for manufacturing cement when or if it was eventually built.

BUILDING PLASTERS. The bulk of these have a gypsum base, gypsum being a naturally occurring material found in many parts of the world. There are many varieties which, under the B.S. system, are divided into classes. The main divisions are:

Class A plaster. This is usually called 'plaster of Paris'. To produce it, gypsum is burnt to a fairly low temperature (160 °C) when it loses most of its water of hydration. When the finished plaster is mixed with water it sets very quickly, usually within 5 minutes. Plaster of Paris is extensively used in plaster casting shops. Here prefabricated panels and mouldings are prepared, reinforced by wood laths and hessian scrim. These are transported to the site and nailed or screwed to wood grounds or bearers, which are shaped if necessary. The joints are then neatly filled with gauged plaster. Much fine plasterwork is carried out in this way.

Class B plasters. These are plasters in which the 'set' has been retarded, i.e. the setting time increased. This allows the plasterer time to lay on the material and bring it to a smooth finish. There are usually three grades of Class B plaster available: undercoat, finishing, and dual purpose, the latter being most widely used, particularly when the plaster has to be imported.

Class C plasters. These are normally of better quality than those of Class B. They are made by heating gypsum to a higher temperature than 160 °C. This causes the plaster to lose its quick-setting power. Accelerators are then added which cause the material to set more quickly, while still leaving enough time to allow the plasterer to obtain a smooth finish.

Class D plasters. The main plaster in this group is Keene's cement, a high-quality slow-setting plaster giving a smooth marble-like finish. Adhesion of decorative finish on Keene's, or Parian, cement is very poor unless a coat of sharp oil-paint is applied as soon as it has set

Other types. Class B, C and D plasters should be applied to backgrounds as undercoats and or finishes in accordance with the recommendations given in Mixes. Other type of plaster, however, are available which may be applied to any surface including concrete, blockwork, or plasterboard. Lightweight plasters are also available with improved acoustical and insulating properties. For information on these, the reader is referred to D.O.E. Advisory Leaflets, B.R.E. publication, etc.

SAND Sand is a fine aggregate, resulting from the natural disintegration of rock. Sand for plastering should be reasonably free from loam or vegetable matter, clay, and saline matter. Frequently, however, masons and plasterers (who are often one and the same) have to use whatever sand is available.

There are some simple tests for checking impurities in sand. One is to rub a sample between the hands or in a white cloth and note whether it leaves a stain. Another test for clay or soil is to rub a portion of sand between the fingers and see whether it forms into a ball. A simple test for determining impurities from silt is to put some sand into a glass jar, preferably with a lid, cover it with water to a height of several centimeters, shake vigorously, and allow to settle. Should a thick coating of scum form after settling then the sand should either be washed clean or rejected. Washing sand will also help to remove salt. Salt tends to create efflorescence, an unsightly crystalline deposit on the finished work which frequently reappears after brushing off. Sand

False ceilings. Metal lathing

Fig. 2.1 Metal lathing

Fig. 2.2 Metal lath angle fillet

Figs.2.3 and 2.4 False ceiling of timber
A 50 mm × 32 mm hardwood hangers
B Concrete ceiling
C Annealed binding wire

Figs.2.5 and 2.6 False ceiling of light steel
A 50 mm × 3 mm hanger at 1200 mm c/c
B 75 mm × 75 mm × 10 mm m.s. angle
C 38 mm × 38 mm × 5 mm angle at 300 mm c/c
D Tying wire

Fig. 2.7 False ceiling metal–alternative sections

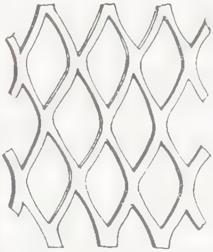


Fig. 2.1

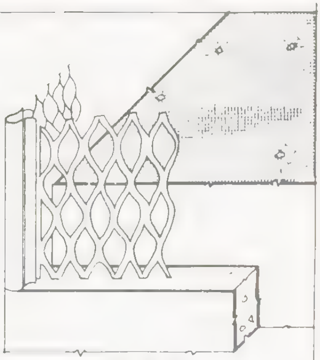


Fig. 2.2

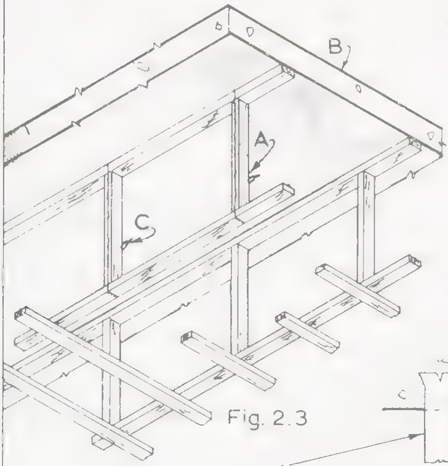


Fig. 2.3

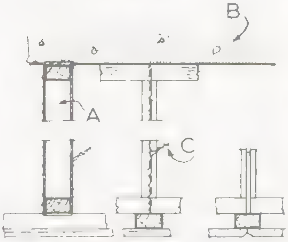


Fig. 2.4

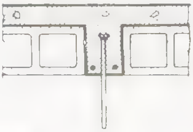


Fig. 2.6

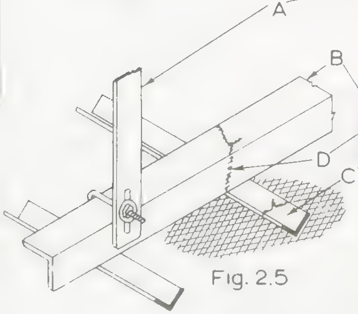


Fig. 2.5

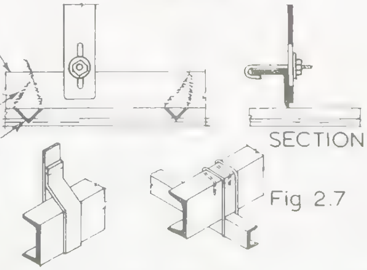


Fig 2.7

FALSE CEILINGS – METAL LATHING

may be washed in the same way as aggregate, as explained in Volume 1, if no other method is available. Where coarse and fine sands are available in the same area they may be graded, i.e. mixed together to give a workable mix. For further tests on soils see Chapter 7. It is as well, however, to be realistic and set up sample panels of mixes with unwashed sand in case the washing routine fails. In some instances washing appears to make no difference.

LATHING. Where it is cheap and plentiful split bamboo is still used as a base for plastering. Sometimes it is woven into mats and nailed into position, though this method is not now common in modern building. It gives an uneven surface and needs a rather thick coat of rendering of haired plaster for a good finish.

Metal lathing is widely used today. It consists of sheets of metal which are punched by machine to give slits or cuts at regular intervals. The sheet is then stretched outward to produce a diamond-shaped mesh of metal as in Fig. 2.1. Expanded metal may be obtained in a wide variety of thicknesses and sizes and is used in many different ways. The most popular size for lathing is No. 26 s.w.g. metal with a 6 mm mesh. The principal varieties are illustrated in B.S. 1369 and the minimum weight is $1{\cdot}2$ kg/m^2, except for lightweight plasters, etc. The sheets are normally about 2700 × 600 mm, but standard sizes are not laid down.

Metal lathing can be cut fairly easily with hand shears and nailed to bearers which may be shaped or curved as desired. One popular use is for false ceilings in either new or existing buildings, Figs. 2.3 to 2.5. Apart from improving insulation, false ceilings can also form a duct for service pipes, ventilation, etc., while in old buildings it can improve the proportions of rooms where ceilings are high. (It was once believed that high ceilings were cooler.)

Figure 2.3 shows a method of constructing a false ceiling in either new or existing work. The grounds are 50 × 32 mm throughout. The ceiling bearer is plugged in place, annealed binding wire having been placed over the bearer before fixing. The wire is windlassed to hold the assembly tight and then stapled in position. This method may also be adopted for fibreboard ceilings; it is not fire resistant however. Where wood grounds are not desirable, light steel angle or channel sections may be used, Figs. 2.5 to 2.7.

Timber hangers *A* are spaced normally at 600 mm centres but steel hangers can be placed at twice this distance. These are usually built into the floor during construction.

Exercise 2.1 Give a working drawing of a false ceiling to be constructed in an existing building where the ceiling is to be lowered by 600 mm. The existing floor consists of wood joists 50 mm thick at 356 mm centres.

Metal lathing may be nailed or wired in position on to grounds not more than 300 mm apart. The edges may be butt jointed or lapped as desired. When using Keene's cement care must be taken to avoid rust spots due to the plaster coming into contact with unprotected metal wire, etc. Where this occurs the spot should be cut out and the wire coated with shellac before being refilled.

Metal lathing can also be used as permanent shuttering to concrete giving an excellent key to plaster. Special fine-mesh lathing is available if required. Angle fillets, too, are often used to protect and strengthen exposed plaster arrises as in Fig. 2.2 and Volume 3. Care must be taken, when plastering on lathing, to avoid making the first coat too strong, otherwise cracking will result (see Mixes).

PLASTERBOARD. This gives an excellent background for plastering. It is machine-made in sheets 9·5 mm and 12·7 mm thick sandwiched between two layers of paper. Normally only one finishing coat is needed and self-finished board is also widely used. Several jointing methods are in use as described in Volume 3. If a finishing coat is required, the joints are left wide enough to take a filling of gypsum plaster and coated with hessian scrim before the finishing is applied. Sheets are normally 2400 × 1200 mm and are easily cut with a blunt saw; they are then fixed with galvanized clout-headed nails.

Fibreboard is also popular. This may be plastered but is often left uncovered after being nailed or spring-stapled in position, and joints taped. It takes emulsion paint quite well, and stands up well in warm climates.

2.3 Plasticizers

In order to strengthen the adhesion of plaster and improve workability, a wide range of additives is available. These are particularly useful in countries where lime is scarce. Plasticizers are water-repellent and are useful for external walls exposed to driving rain, e.g. walls behind open blockwork screens, or where rooms are converted to terraces by the use of sliding partitions, etc. The proportions vary but it is claimed with one variety that a 5 gallon (22·72 litre) drum will replace 2 tonnes of lime. For further information on plasticizers the reader should consult *Specification* or write to the Building Centre, London.

2.4 Mixes

The three main materials in general use are Portland cement, lime, and gypsum plaster. For internal work Portland cement and sand is used only where lime is not easily available or where a building is designed on an open plan. In some areas, e.g. parts of West Africa, all internal renderings are of Portland cement and sand; no other material is used even for a finishing coat. The practice is costly in cement and does not provide for a smooth finish, particularly when application and finishing are done with only a mason's trowel and straightedge. The plasterer's laying-on trowel, however, is now being more widely used.

Lime may be added to either Portland cement or gypsum plaster, but Portland cement must not be mixed with gypsum plaster. Usually Portland cement/lime/sand is reserved for external work and gypsum plaster for internal, though there are many exceptions to this practice – see Plasticizers above and West African practice. Gypsum plasters are also used externally where cement is unobtainable. Fat lime, however, will not withstand rain, and hydraulic lime is more difficult to work.

For high-class interior work, hotels, public buildings, and official residencies, the best finish is usually obtained by the use of a Portland cement and sand rendering with a finishing coat of Keene's cement. This gives a hard smooth finish. The most common mixes are given in Table 1, but these should be taken only as a general guide. In some cases site conditions may require stronger mixes. Where two types of background are to be found in the same room, one mix suitable for both should be used if possible.

2.5 Key

Adhesion of plaster to background is very important. Concrete should be cleaned free of grease or film and either hacked or painted with an epoxide resin adhesive. Alternatively, this may be added to the mix according to the maker's instructions. Each coat of plaster should be scratched or grooved, the top undercoat only lightly so.

2.6 Finishing coat

This should not be applied too thickly; one coat about 2 mm thick is usually sufficient. Undercoat thicknesses vary, but about 10 mm to 12 mm is usual.

CERAMICS, GLASS MOSAICS

2.7 Introduction

A wide range of finishes is now available, with new materials constantly being introduced. Changing fashions, new ideas, developments in prefabrication, cost, and the economic state of the community all affect demand. Only the basic finishes are dealt with here. The reader is advised to keep himself up to date by reading journals and building literature and, where possible, visiting exhibitions and displays of products.

Table 1

Background	*Undercoat*	*Finish*
Brickwork or blockwork	(1) Cement/lime/sand 1:2:6	Lime/gypsum Class B 1:$\frac{1}{2}$ (*R*)
	(2) Cement/sand 1:4	Gypsum C neat (*S*)
	(3) Gypsum B/sand 1:3	Lime/gypsum B 1:$\frac{1}{2}$ (*T*)
	(4) Gypsum C/lime/sand 2:1:6	*R*, *S*, or *T* above
Concrete cast *in situ*	As (2) above	As *S* above
	As (3) above	As *T* above
	If none needed	As *S* above
Metal lathing	As (1) above (two coats)	As *R* above
	As (3) above (two coats	As *T* above
Expanded plastic sheets, plasterboard or fibreboard	None usual (except joints)	As *R* above
Wood-wool slabs	As (1) above	As *R* above
	As (3) above	As *T* above

GLAZED TILES These come under the heading of 'ceramics', and the art of pottery is one of the oldest in the world. Modern tiles, however, bear little resemblance to ancient wares. They are now usually machine-made from many different clays to give great density, little shrinkage, and, if desired, high glaze. These carefully prepared clays are moulded in heavy presses then burnt at high temperature and, after cooling, sorted into grades. The unglazed tiles are then stored and glazed as required. This is done by adding liquid glaze designed to give the desired finish, after which the tile is refired.

Tiles are normally about 6 mm thick and made in a variety of sizes and are either square or oblong. The usual sizes range from 100 mm square to 150 mm square. Ancillary fittings are available to deal with internal and external angles, corners, etc., as in Fig. 2.10. Bathroom and kitchen fittings are also made to match tiling. These include soap dishes, toilet-paper holders, tumbler recesses, shelf brackets, grab handles, towel rings, etc.

Glazed wall tiles may still be fixed by first soaking the tiles in water until the air bubbles cease and then bedding on a cement sand mortar, 1 : 2½ rendering with the same mix. Most tiling, however, is now bedded in adhesive (see paragraph on adhesives).

DECORATIVE PATTERNS The wide range of patterned tiles in standard sizes are also on the market. These are made in attractive designs and by using one or more matching tiles can be used to form larger patterns as Fig. 2.8.

Tiles can be obtained in varying degrees of hardness depending on their purpose. Some floor tiles contain an abrasive, added during manufacture, which makes them suitable for heavy foot traffic in public places, entrance halls, corridors, and patios. Such tiles are normally unglazed.

Textured surface tiles are also in particular demand. With these, the pattern stands out in slight relief giving an effective finish. Decorative texture tiles are also popular, as in Fig. 2.9. They can be bought singly or in sets for bedding either in uniform patterns or at random, usually in plain-tiled walls.

CERAMIC MOSAICS In recent years the use of ceramic natural clay tiles, both glazed and unglazed, has become common for walls, floors, and ceilings. These can be obtained in a wide range of ready made patterns or they can be customer-designed to order. The tiles range in size from 19 mm square to 50 mm square and are mounted on stiff paper which is stuck to the exposed face of the tiles and peeled off after fixing. They may also be mounted on a water-resistant backing secured to the back of the tile. Murals, mosaic patterns, lettering, etc., can be built up by using tiles of different colours, as in Fig. 2.11 and Volume 3. A full range of trim tiles is made to deal with angles, corners, coves, etc. Tiles are also available in a hexagonal shape. Ceramic tiles, especially the smaller sizes, can be readily fixed to curved surfaces such as columns.

ADHESIVES. Ceramic tile adhesives have now been developed which will fix tiles to any rigid surface, e.g. brick, concrete, hardboard, plaster board, or old glazed tiling. They are useful in warm climates as they can be used on hot surfaces up to 88 °C or in hot atmospheres where cement and sand would fail. Adhesives should not, however, be used on surfaces likely to remain permanently damp.

Where surfaces are uneven, they can be levelled out by skimming over with a mixture of sand and tile adhesive 2 : 1. Not too large an area should be spread at one time, say, 1 m^2. The adhesive should be spread thinly and tiles pressed into position. They should not be soaked first.

MARBLE. Marble is held in high regard as a building material throughout the world, and is usually associated with high-quality construction. It is used extensively in good building, both internally and externally, for walls, floors, and sometimes ceilings. It is much favoured in warm countries, being clean and cool in appearance. Perhaps the most famous building in marble is the Taj Mahal, India.

Marble linings are used internally in public buildings, hotels, banking halls, official residences, offices, etc. Because of its cost, it is usually cut into thin slabs which can be secured to backgrounds in a number of ways: the most usual is to bed the slab with pats of plaster and then secure it firmly with non-ferrous anchors, usually of brass or copper, though stainless steel is also widely used. Two anchors should be put in every 600 m^2. In earthquake areas particularly, mechanical anchors are essential.

In order to produce the best effect, marble is cut to show the grain, Fig. 2.20. This is done by sawing the blocks into slabs and opening adjacent pairs like a book to produce a matching effect. In some countries translucent marble is obtainable. This produces a restful subdued light and is much in demand for chapels and places of rest or as a relief from glare. Strong electric lighting placed behind translucent panels can be used to produce dramatic effect.

Marble laid over large areas of walls and floors should have expansion joints at 6 m intervals. These are normally 10 mm wide, and usually made of a non-staining elastic compound such as polysulphide. Sometimes the bottom half of the joint is filled with cotton rope or sponge rubber and the top half with synthetic rubber filler. Joints in walling are usually of lime cement mortar 3 mm thick. For 32 mm slabs the joints should be about 5 mm thick. Where internal walls are subject to driving rain through open screens, etc., the slabs should be bedded in lime cement mortar 1:1:6 rather than plaster of Paris. Floors subject to constant washing or in contact with water are best finished as in Fig. 2.18. The plinth or skirting may be copper lined or of terrazzo if preferred.

Exercise 2.2. To a scale of 1/25 F.S. or thereabouts draw the plan and elevation of a marble pier shown in Fig. 2.20. Show clearly the method of securing the slabs to the concrete background without using timber grounds.

Terrazzo is very popular for internal work, particularly in the tropics. It can be applied to a background of concrete or masonry or, if desired, on partitions or metal lathing as in Fig. 2.25. It can be shaped to suit most building requirements, e.g. counters, columns, and curved surfaces. The metal studding should not be more than 300 mm apart and the finished thickness of all coats should not exceed 50 mm. Dividing strips are constructed as described in *Floors*, Volume 1. These may be of plastic or half-hard brass 3 mm thick bedded in the second coat. Terrazzo partitions should preferably be machine-rubbed to bring them to a smooth surface.

MOSAIC. The art of mosaic laying is very old indeed. Many fine panels, particularly floors, have been unearthed in recent years. It is still, however, contemporary practice and much in demand in all types of building. Mosaic patterns are formed by transferring the artist's detail on to the surface to be treated. This can be done by dividing the drawing into small squares which are then re-drawn on the background as guidelines. Small pieces of mosaic are then bedded in wet mortar using the guide lines to keep the pattern, colour mosaics often being used to bring out the detail. Pieces vary in shape, but are usually about 25 mm square or less. This is very skilled work. Figure 2.15 shows the partly-finished head and claw of a dragon. It was taken from a design for Watney's Brewery, London. For those visiting London, Westminster Cathedral has some exceptionally fine mosaic work. For small areas the mosaic is sometimes secured to stiff paper as described for ceramics. This is then bedded in wet mortar and the paper peeled off when dry.

P.V.C. tiles are used extensively on walls as they are comparatively cheap, easy to fix, and of clean appearance. They are available in a wide range of colours and sizes. The procedure for laying, explained in *Floors*, Volume 1, may also apply to wall finishes. The tiles, however, should be protected from excessive sunlight and damp conditions, although they are quite suitable for domestic bathrooms.

GLASS. Coloured plate-glass as a finish has been available for many years and a wide range of colours is available. The glass panels are bedded with plaster dots using the method described for marble, and cover strips of metal, plastic, or wood fixed over the joints to hold the glass in position. Alternatively, the glass may be bedded in adhesive. Translucent patterned glass is also available for internal decoration, where privacy is desirable, being suitable for room dividers, office partitions, and screens.

Glass blocks have long been used in external walls. A modern version of these, useful in the tropics, consists of hollow glass building units made up into grilles or internal partitions. They consist of hollow concrete blocks, square or rectangular, with shaped cavities each of which is fitted with glass, coloured or patterned as described. The blocks are bedded in mortar. They are also useful for matching existing open screening where privacy or weather protection is needed.

INTERNAL JOINERY

2.8 Introduction

Although some tropical countries now have extensive joinery works, by far the largest proportion of internal fitments are still produced by hand in small or medium-sized workshops. For this reason the 'cabinet-maker' type of finish is rare except when mass-produced items are readily available.

DOORS. This subject has been dealt with both in Volumes 1 and 3 but the following description of doors is necessary here.

Flush doors. Many types of interior door are produced. They may be of special lightweight type built with a cellular core consisting of resin-impregnated corrugated paper expanded into honeycomb sections as in Fig. 2.26.

Solid-core timber doors are also in demand. These may be constructed by inserting as a core lightweight, hardwood battens machined to form narrow strips and assembled with the grain running alternately. The vertical edges are lipped and sometimes double-tongued to the stiles, as in Figs. 2.28 and 2.29. It is necessary to specify whether one or all edges should be lipped. Cheap doors are sometimes not lipped at all.

Cellular or skeleton-frame doors need to have inserted lock blocks and any other blocks which may be necessary, e.g. blocks for door springs, kicking plates, or other fittings.

The finish may be supplied for painting or the surface covered with decorative veneer. Laminated plastic suitable for bonding to wood may also be specified. A popular size of internal door is 750 × 1950 mm, and it is of course cheaper and more efficient to keep to one size where possible.

Sliding doors of wood These have a long history both as internal and external doors and also as partitions. Sizes can vary from small cupboard doors with slides as guides to power-operated sliding/folding leaves for industrial use. An aircraft hangar door is typical of the latter. Some larger doors are shown in Volume 3. Here we shall confine ourselves to one single type suitable for domestic use. Figure 2.31 shows a method of hanging the door or leaf by suspending it from runners which roll smoothly on the track shown. Figure 2.30 shows a section of a heavier door. Many accessories are available, e.g. pelmets, door stops, overhead brackets for securing tracks where required, floor guides or grooves. These doors are excellent for partitions, and curved tracks can be supplied to steer the leaves around corners.

When local joiners are making doors, the sliding door gear manufacturers' instructions and working drawings must be adhered to. The reasons for their recommendations, e.g. off-centre t. & g. leaves, may not be immediately obvious and therefore ignored with unfortunate results. The gear itself allows for every adjustment, vertical and horizontal, so hanging is relatively simple.

Metal sliding doors Doors of extruded aluminium alloy are now popular in warm countries both for internal and external use. The panels slide smoothly on ball-bearing rollers, and the door furniture is supplied complete, including a cylinder lock if desired. The finish may be optional. Usually the metal is etched and coated with clear lacquer, but it may be anodized as described in Volume 1.

The glass is secured by a vinyl glazing strip to accomodate thicknesses

Ceramics. Mosaic

Fig. 2.8 Ceramic tiles

Fig. 2.9 Hand-painted decorated tile

Fig. 2.10 Tile fittings

Figs. 2.11 to 2.14 Ceramic mosaic

Fig. 2.15 Mosaic panel

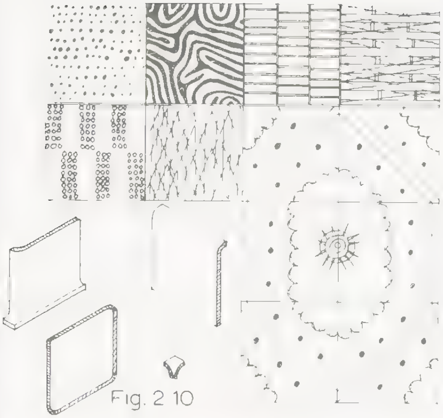


Fig. 2.8

Fig. 2 10

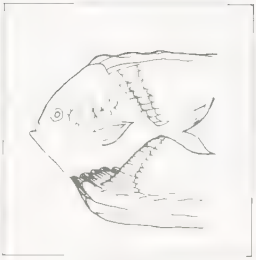


Fig 2 9

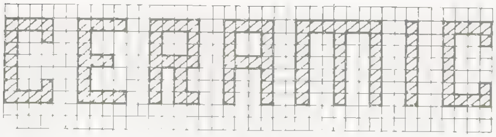


Fig 2.11

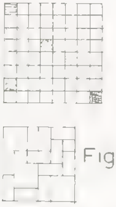


Fig 2 12

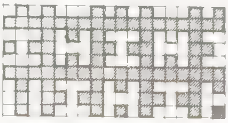


Fig. 2 13

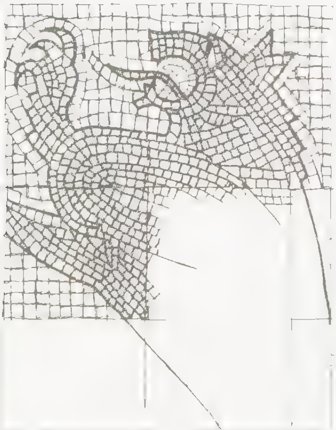


Fig. 2.15

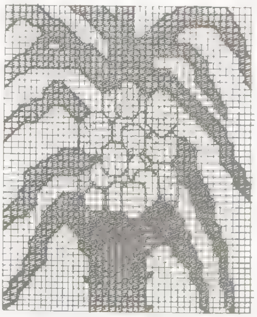


Fig. 2.14

CERAMICS-MOSAIC

of 3 mm–6 mm. Double glazing or solar control glasses can be supplied if desired. Where doors are to be imported they are usually supplied k.d. and packed in one carton. Glass is not supplied in such cases. Fly-screens may also be supplied if required. These are fitted with gliders or rollers at head and sill for smooth operation. Figures 2.32–2.35 give details. The doors are supplied in various sizes depending on the number of panels used; a good average size for an internal domestic door or partition would be 2 m long × 2–2·5 m high.

Marble and terrazzo details

Fig. 2.16 Marble detail
  A 32 mm floor slab
  B 25 mm wall slab
  C Jointing compound

Fig. 2.17 Elevation of marble lining

Fig. 2.18 Marble detail for external work
  D Copper-lined or terrazzo skirting

Fig. 2.19 Plan of corners and reveal
  A Wall slab
  B Non-ferrous anchor
  C Door frame
  D Expansion joint

Fig. 2.20 Grained marble slab on hardwood grounds

Fig. 2.21 Detail to foot of above

Fig. 2.22 Plan to end feature of above
  A Stainless steel panel
  B Non-ferrous anchor

Fig. 2.23 Section through top of above

Fig. 2.24 Non-ferrous anchors

Fig. 2.25 Terrazzo wall and floor tiling
  A Metal lathing
  B 75 mm × 50 mm studding
  C Plastic or brass strip

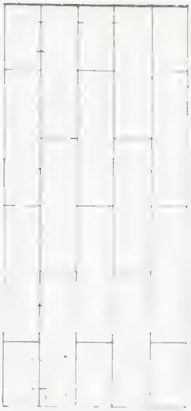


Fig. 2.17

Fig. 2.24

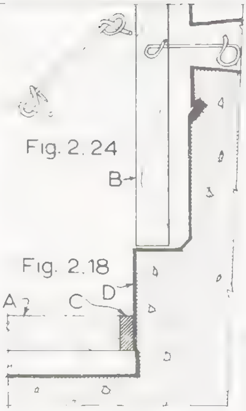


Fig. 2.18

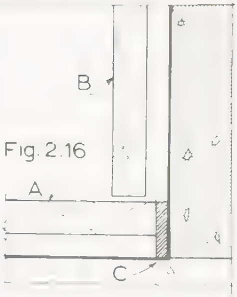


Fig. 2.16

Fig. 2.24

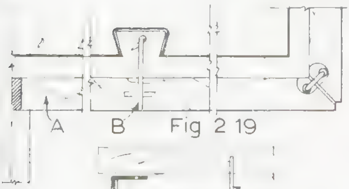


Fig 2 19

Fig. 2.24

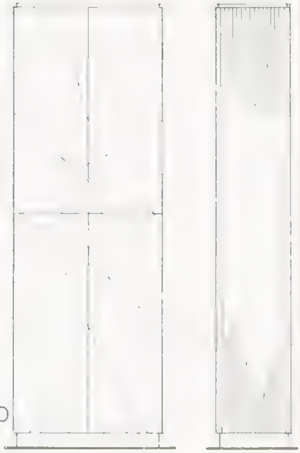


Fig. 2.20

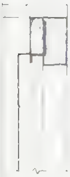


Fig 2.23

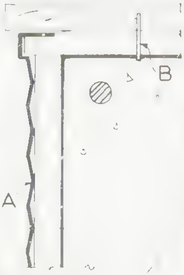


Fig. 2.22

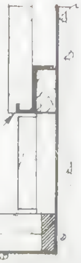


Fig. 2 21

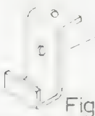


Fig. 2.24

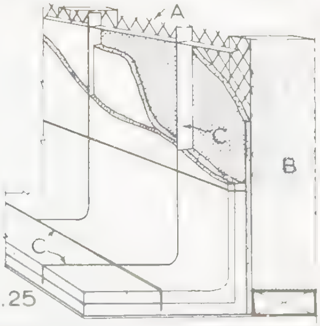


Fig. 2.25

MARBLE and TERRAZZO DETAILS

INTERIOR ROOM DIVIDERS. Dividing up large interior areas into smaller units in frequently necessary in public buildings, hotels, schools, hospitals, etc. The type of partition used will depend upon the individual need and the degree of permanence required. Collapsible, quick-moving, sliding partitions which are now enjoying some popularity are shown in Figs. 2.36–2.44. They can be of extruded aluminium, or a heavy galvanized framework covered with fabric, or hinged wooden leaves covered with plastic.

The aluminium panels shown in Figs. 2.37 and 2.38 are about 100 mm wide. They are connected by extruded vinyl hinges, each panel supported by a nylon-tyred bearing roller. The door is shown in a closed position. No floor track is needed except for very large doors. The finish gives a choice of three colours. Panels are anodized as described in Volume 1, and sizes range up to 2 m wide and about 5 m high. Doors can be supplied singly or in pairs; and cornice *B* may be added to one or both sides if required. The packing space for these doors is about one eighth span plus the lead post. Spaces may also be divided into three or four areas by means of a meeting post suspended from the track at the desired point of intersection. It can be removed when not required.

A heavier type of *collapsible door* is shown in Fig. 2.40. It is of rust-proof steel and comprises a jamb post and lead post connected top and bottom by means of hinged plates and rods as shown. Heavy-duty doors have special ball-bearing rollers provided. A typical track is shown in Fig. 2.42. These doors are supplied in several sizes and will divide a room up to 40 m wide and 6 m high. Floor channels are used with the larger sizes. Special ironmongery and door furniture are obtainable to suit requirements. The overhead track can be built flush with the ceiling and can be curved as required. Partitions can then be switched on to different tracks by means of 'points' making the system flexible, which may help to ease storage problems.

Folding doors are also available with a *pantograph mechanism*, as in Fig. 2.43. They can be supplied in heights up to 2·5 m, and widths

Door details

Figs.2.26 to 2.29 Flush doors

Fig. 2.30 Sliding door gear (garage)

Fig. 2.31 Sliding door gear (domestic)

Figs.2.32 to 2.35 Details of aluminium sliding door

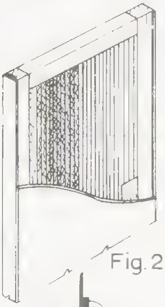


Fig. 2.26

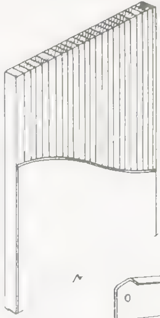


Fig. 2.27

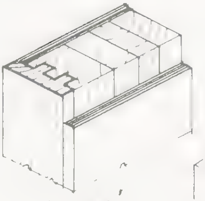


Fig. 2.28

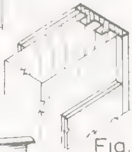


Fig. 2.29

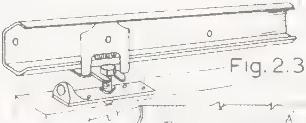


Fig. 2.31

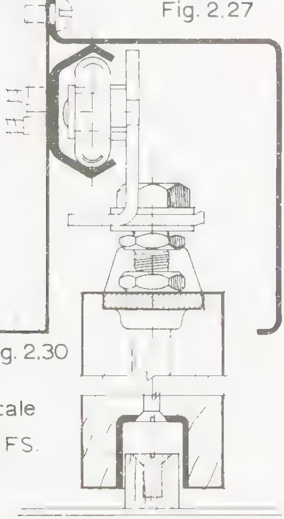


Fig. 2.30

Scale
1/2 F.S.

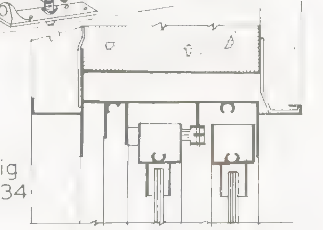


Fig
2.34

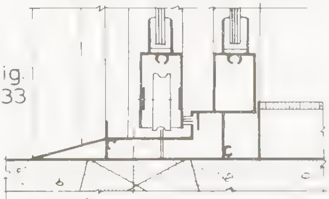


Fig.
2.33

Scale 1/8 F.S.

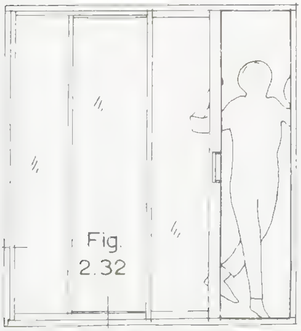


Fig.
2.32

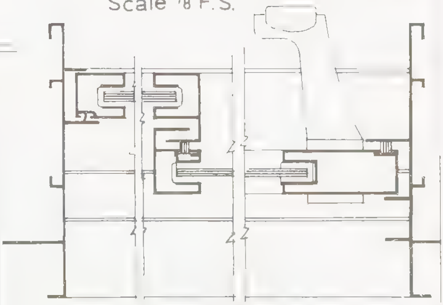


Fig. 2.35

DOOR DETAILS

up to 2·5 m per door. Pairs of doors are usually supplied. The leaves consist of hardwood panels covered with vinyl. Nylon slides are usual for the smaller sizes of door, but the larger doors have a heavyweight track and guide-wheels with steel bushed swivel mounts.

The door shown in Fig. 2.44 is made of lightweight materials, and covered with P.V.C. leathercloth which is supplied in a range of colours. The materials are not affected by tropical conditions, being resistant to humidity, fungal growth, and mildew. Further examples of doors are given in Volume 3.

INTERNAL JOINERY. Space does not permit extensive discussion here, but the simple examples given should serve to give the reader some knowledge of the basic principles of construction, particularly when using local hardwoods.

The *room divider* shown in Fig. 2.45 illustrates an openwork design, which permits air circulation and gives an unobstructed view. The cupboard can be opened from either side, and the steel supports allow wide shelving to be used without any danger of damage if shrinkage or warping should occur. The cupboard is detailed in Fig. 2.47a and is shown with glass doors on one side and plywood on the other. Hardwood grooves, plastic runners, and glass panel framing are also shown.

A typical *kitchen unit* of basic design is given in Fig. 2.49. The doors are of blockboard with a false mullion at *A* attached to one leaf to preserve a uniform appearance without presenting an obstruction. The suggested answer to Exercise 2.3 shows an alternative method. The surface may be covered with Formica or similar laminate if desired.

Exercise 2.3. Using Figs. 2.49 and 2.50 as a guide, prepare a working drawing of a kitchen unit in sufficient detail to enable it to be built complete in a joiner's shop, prior to fixing on site.

DRY FINISHES

2.9 Introduction

The use of mortar mix finishes for walls, ceilings, and other surfaces, although widespread, is not as popular as it once was. The process of applying wet mortars to walls, while being comparatively cheap in areas where this method is used traditionally, has certain disadvantages which are not always acceptable in modern construction. These include the general untidiness of the procedure, the lack of skilled personnel capable of producing a first-class finish, the poor quality and bad mixing of materials, the time taken for walls to dry out, the efflorescence which appears on surfaces when salt is present, and the lack of a 'true' surface, which causes dimensions to vary. This last situation can be expensive where fitments have to be scribed or packed out to meet the wall. The greatest single drawback, however, is the permanence and inflexibility of partitions built in this way. To overcome this and other disadvantages dry wall-finishes have been introduced.

DRY PARTITIONS. These are widely used and can be faced with a variety of materials: metals, glass, plastics, hardboard, or other sheet materials. Figure 2.51 shows a louvred partition with an infilling of sheet material secured to studs. The sheets in this instance are of fibreboard or plywood. The louvres, which may be of wood, glass, or metal and either pivoted or fixed, are placed on top and bottom to facilitate ventilation.

WALL LININGS. There are numerous methods of fixing linings to walls. Figure 2.52 shows a decorative melamine wallboard on hardwood grounds with a plastic cover-strip held with impact adhesive. Panel pins are also used for extra security. Alternatively, wood or metal cover-strips may be used which are nailed or screwed through the expansion gap. Clip-on metal cover-strips may also be used as shown at *C*, Fig. 2.53.

Bonding direct to masonry walls is not recommended. Battens, 50 × 25 mm, plugged to the wall give a truer finish with better security, especially if the walls are subject to considerable changes in temperature. Metal or plastic cover-strips may also be used as shown in Fig. 2.54. Sheets may be obtained in various sizes, the most usual being 2400 × 1200 mm.

Laminated plastics are also in wide use for covering furniture, fitments, and fixtures, especially in public buildings, hospitals, restaurants, hotels, schools, etc. The larger manufacturers of plastics publish extensive literature on the subject and will produce finished colour schemes if desired. Figure 2.56, a serving counter in a canteen, is an example of clean and simple design. The plastic facing is secured to any type of suitable block or composite board of good quality.

MOVABLE PARTITIONS. Owing to the need for flexibility and change in room design in modern building, internal non-loadbearing walls are frequently made to permit of rapid dismantling and re-erection. Although different in detail and in use of materials, the principle is similar with most makes. Figure 2.57 shows a typical plan and section. This is termed 'double wall' construction with extruded aluminium head *B* and sill *A* and perforated aluminium studs erected at intervals of 1200 mm to support the panel edges.

Another type of partition consists of two gypsum plasterboard skins held about 50 mm apart by means of a light metal membrane. This system has good sound insulation properties and is quite suitable for offices and spaces not subject to heavy wear.

A further type of demountable partitioning is one which makes use of compressed air to hold itself in position. The air is pumped by hand bellows into a telescopic cap at the head of the partition, raising it to fit tightly against the ceiling. Most movable partitions have provision made inside them for electrical, telephone, and other service installations.

HEAT INSULATION. In tropical countries heat insulation plays a very important part in comfort control. The quality of insulation depends on the degree to which the material or construction has the property of resisting the passage of heat from one face to another. A widely-used material recommended for this purpose is *foamed plastic*. It is rot-proof, fire resisting, vermin proof, and has a high degree of insulation. It may be supplied as loose fill, packed as stout paper quilts, or as paper covered blocks with edge flaps which may be stapled to wood surrounds. The blocks are supplied in various sizes.

Figure 2.58 shows typical insulation to a timber-frame building. Floor or roof insulation is shown in Fig. 2.59. This kind of insulation in floor construction can also be used to reduce the passage of sound. Figure 2.60 shows similar construction, using loose fill *D* and, alterna-

Continued on page 50

Folding partitions

Fig. 2.36 Folding partition

Figs. 2.37 and 2.38 Collapsible sliding partition

Fig. 2.39 Overhead track *A* and pelmet *B*

Fig. 2.40 Heavy-duty collapsible partition

Fig. 2.41 Detail of overhead roller

Fig. 2.42 Overhead flush track

Fig. 2.43 Pantograph mechanism

Fig. 2.44 P.V.C.-covered timber partition

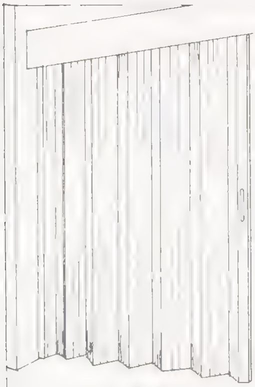


Fig 2.36

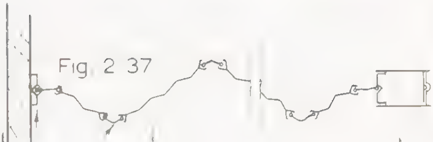


Fig. 2.37

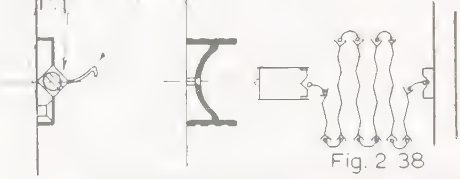


Fig. 2.38

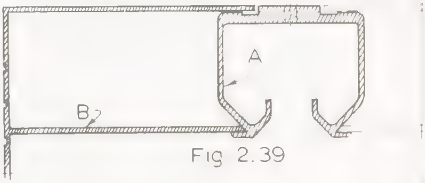


Fig 2.39

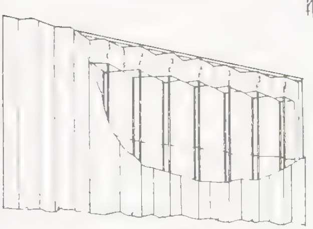


Fig. 2.40

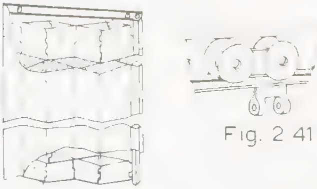


Fig. 2.41

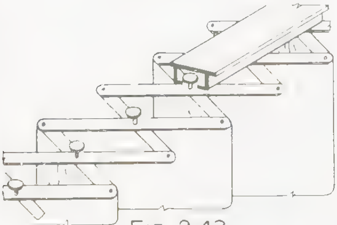


Fig. 2.43

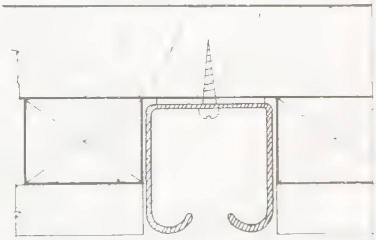


Fig. 2.42

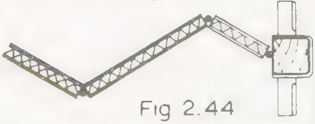


Fig 2.44

FOLDING PARTITIONS

Joinery details

Fig. 2.45 Openwork room divider

Fig. 2.46 Steel rod support for shelving

Fig. 2.47a Section through cupboard
- *A* Blockboard sliding doors
- *B* Glazed cupboard doors
- *C* Plastic or hardwood runner
- *D* 25 mm hardwood top

Fig. 2.47b Glass sliding panels

Fig. 2.48 Details of glazed door

Fig. 2.49 Basic kitchen unit
- *A* False mullion

Fig. 2.50a Section through unit

Fig. 2.50b Drawer detail
- *A* 25 mm drawer front
- *B* 19 mm sides and runners
- *C* 7-ply bottom

Dry finishes

Fig. 2.51 Louvred partition
- *A* Wood louvres (fixed or pivoted, glass or metal)
- *B* 45 mm door (flush or louvred)
- *C* Sheet panel–plywood, fibreboard, plastic, laminate, etc.

Fig. 2.52 Wall lining
- *A* 50 mm × 25 mm hardwood grounds
- *B* Wall lining of plastic sheeting, plywood, etc.
- *C* Cover strip held with panel pins and adhesive.

Fig. 2.53
- *A* Spring clips at 250 mm c/c
- *B* Wall board
- *C* Clip-on metal cover strip

Fig. 2.54 Metal or plastic jointing sections
- *A* External corner section
- *B* Internal corner section
- *C* Straight jointing

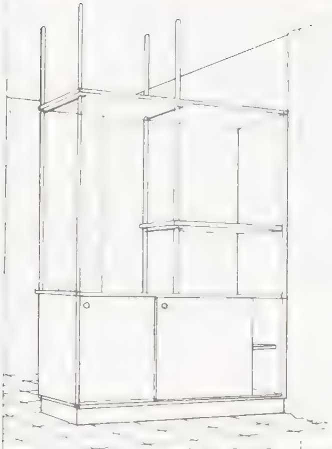


Fig 2 45

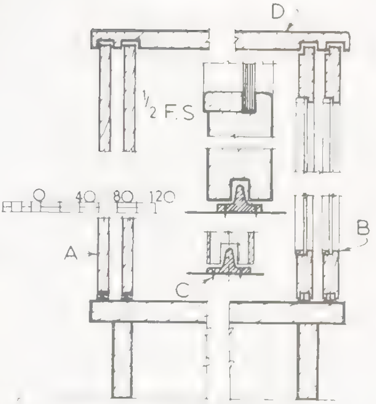
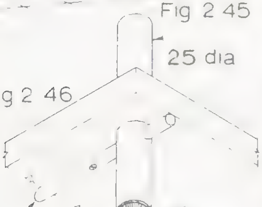


Fig 2 47a



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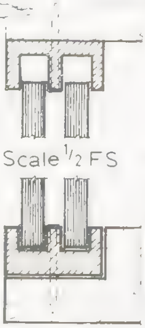


Fig 2.47b

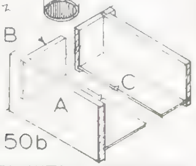


Fig 2.50b

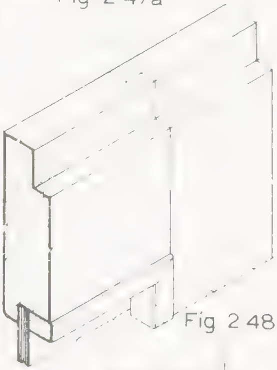


Fig 2 48

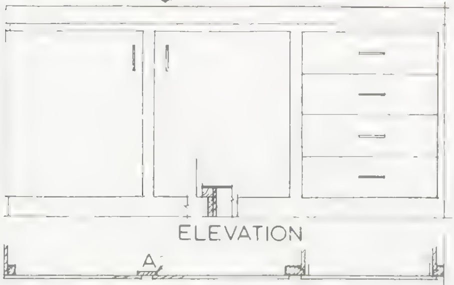
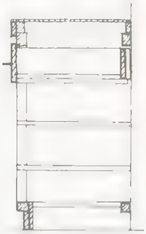


Fig. 2.49



SECTION Fig. 2.50a

JOINERY DETAILS

- Fig. 2.55 Metal cover strip
  - *A* Cover strip and retaining clip: before assembly
  - *B* Cover strip and retaining clip: after assembly

- Fig. 2.56 Laminated plastic counter
  - *A* Formica covered 19 mm composite board
  - *B* Shelves, angle cleat
  - *C* Sliding panels
  - *D* Base of counter

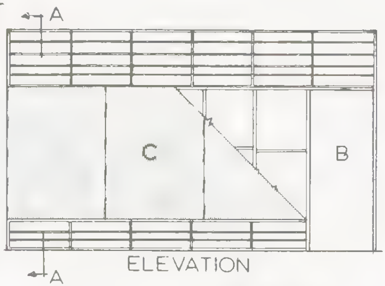
- Fig. 2.57 Movable partition
  - *A* Floor channel
  - *B* Ceiling channel
  - *C* Stud
  - *D* Aluminium or steel trim
  - *E* Door
  - *F* Composite and plastic/metal-faced plywood

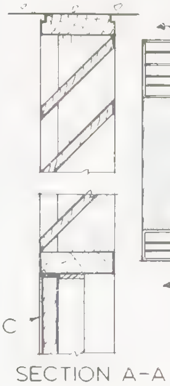
Insulation

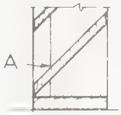
- Fig. 2.58 Timber wall insulation
  - *A* 100 mm × 50 mm framing
  - *B* Timber sheathing
  - *C* Cladding
  - *D* Insulation stapled to joists
  - *E* Finish
  - *F* Lining

- Fig. 2.59 Timber floor insulation
  - *A* Floor joists
  - *B* Building paper
  - *C* Wood sub-floor
  - *D* Hardwood floor finish
  - *E* Wire mesh stapled to joists
  - *F* (Alternative); heavy gauge wire wedged in place
  - *G* Insulation laid on wire mesh

- Fig. 2.60 Timber roof insulation
  - *A* Ceiling joists to roof space
  - *B* Ceiling finish
  - *C* Attic floor (if required)







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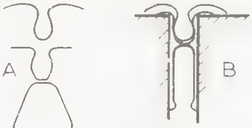
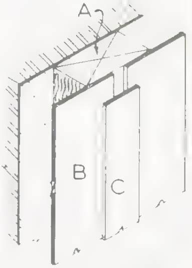


Fig. 2.55



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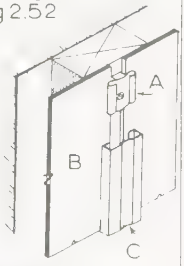

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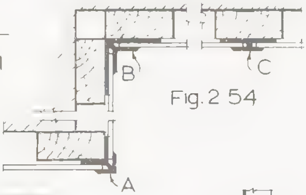


Fig. 2 54

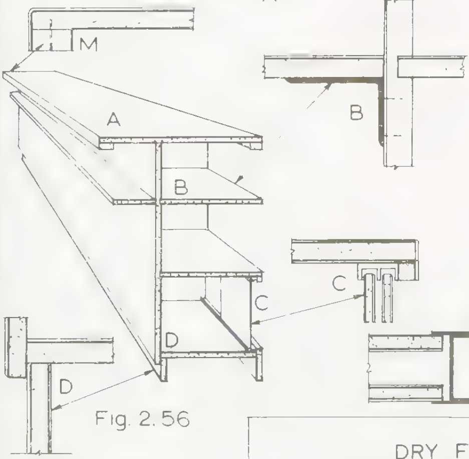


Fig. 2.56

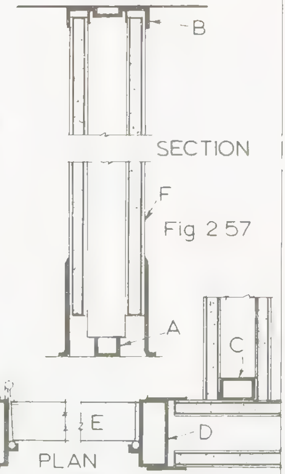


Fig 2 57

DRY FINISHES

tively, paper-covered insulation *E* stapled to joists. Figure 2.61 shows a method of insulation for a flat-boarded roof.

A popular type of roof in tropical countries is shown in Fig. 2.62. The metal decking panels are supplied in steel or aluminium with or without soffit plates. The side edges of the soffit tray are angled to form an overlap. The steel soffit deck is fabricated in 25 mm or 50 mm depths and in widths of 600 mm. Aluminium decking is available in 25 mm 75 mm depths. Fixing is done to wood plates by hammer-driven self-tapping screws or to steel supports by cartridge gun. The steel soffit is usually galvanized, but aluminium is available in leather grain or embossed finish if desired.

Insulation of metals and structures is an important factor in tropical design and construction and warrants further study by the reader.

COLD STORAGE. Low-temperature storage space is in increasing demand as warmer countries become more industrialized. Mechanical aids to temperature reduction can be wasteful unless adequate precautions are taken to control the flow of heat through surfaces. The lower the temperature, the more necessary and difficult it is to prevent heat loss.

A fairly straightforward design for a cold storage unit is shown in Fig. 2.64. This includes the use of *foamglass* blocks laid over walls, floor, and ceiling in two layers, each layer bedded in bitumen. The ceiling slab, Fig. 2.63, may be anchored to the concrete slab by means of hook bolts as shown, and the ceiling plastered with a special mix if desired. For very low temperatures it is necessary to enclose the storage space totally and so prevent heat loss through surrounding wall and surface slab. This is shown in Fig. 2.64 where the foamglass slabs pass beneath the column base. They are strong enough to withstand crushing when used in single-storey construction. The columns may be cased with blocks and bitumen by scribing them to fit around the web and flanges.

Figure 2.66 shows a plan of the door. The sub-frame *B* must be of stout construction and be fitted with a shock absorber *E* to prevent damage to the insulation. The hinges and the door fittings are of a special type designed by cold-room specialists to ensure a tight seal against heat loss. Internal door-latches are also supplied for emergency opening. Warning lights may also be fitted to show when the store is in use.

Exercise 2.4 Using the sections and sketch given, Figs. 2.62 to 2.66, draw a section through the cold storage chamber. Show a section of the door, with floor, walls, and roof complete.

SUSPENDED CEILINGS. False ceilings wet-finished on expanded metal have already been discussed. Their popularity, for reasons of insulation, ducting, room proportion, neat finish, and improved acoustics, has led to a number of ingenious designs, some of which are shown in Figs. 2.67–2.70.

The metal fixings, now more or less universal, have distinct advantages: they provide quick, secure methods of applying sheets and fibreboard to any form of structure, including if necessary linings of sloping roofs. The illustrations given here, however, cover only flat suspended ceilings. To aid acoustics 'rabbit warren' acoustic panels of grooved fibreboard are available with a perforated (round or slotted) hardboard face to align with grooves and with a plain hardboard backing.

Figure 2.68 shows a pressed P.V.C. laminated sheet tile 600 mm square. These tiles are either plain or perforated, and can be supplied in four different shades. The tiles snap into special tee sections *D* suspended on adjustable rod hangers with supplementary 40 mm channels at 1350 mm centres. Standard infill pads of *fibreglass* are used on the tiles. The average weight of the assembly, including suspension, is less than 10 kg/m^2.

Figure 2.69 shows *insulating plasterboard* with a plastic facing. Gypsum plasterboard for wet-plaster finish is also available. The plastic facing is available in five standard shades. Suspension is by tee and ell section galvanized steel. The panel sizes are 2270 × 600 mm.

Although not strictly a dry finish, a louvre lighting panel is shown in Fig. 2.70d because, in addition to performing its own function of light distribution, it also incorporates many of the features of suspended ceilings. The polystyrene louvres are made in four cell sizes ranging from 10 mm - 50 mm cube approximately and from 600 mm 1200 mm square panels approximately. Finishes to other materials and methods are given in Figs. 2.70a, b, and c.

IRONMONGERY

2.10 Introduction

Ironmongery or hardware covers a fairly wide field and it is possible to include here only those items which have direct bearing on tropical design and construction. Thus, many of the items in common use in all countries have been omitted, e.g. locks, hinges, window-fasteners, etc., as the reader will probably have the opportunity of inspecting these for himself. It is now becoming general practice to make provision for essential fittings such as canopies, curtain tracks, blinds, hooks, door stops, etc., and to install these at the time of building.

Continued on page 56

D Loose-fill insulation
E Quilted insulation stapled to joists

Fig. 2.61 Timber roof decking
A Ceiling joists
B Building paper (vapour barrier)
C Roof boarding
D Rigid insulation
E Built up roofing

Fig. 2.62 Metal roof decking
A Steel or aluminium decking 25 mm to 75 mm deep, 600 mm to 900 mm wide
B Roof rigid insulation
C Built-up roofing

Fig. 2.63 Cold storage roof insulation
A Glass fibre insulation blocks 300 mm × 450 mm, or 450 mm × 600 mm; 50 mm to 150 mm thick
B Cold adhesive or asphalt
C Concrete roof
D 200 mm hook bolt with clip retainer

Fig. 2.64 Cold storage space
A Masonry
B Steel column (cased if required)
C Floor slab
D Glass fibre insulation bedded in adhesive
E Surface concrete
F Steel joists (*see* Fig. 2.62)
G Built-up roofing
H Bitumen felt slip

Fig. 2.65 Section through cold store

Fig. 2.66 Plan of door to cold store
A Masonry
B Heavy wood sub-frame
C Door lining
D Glass fibre insulation
E Rubber buffer
F Sealer

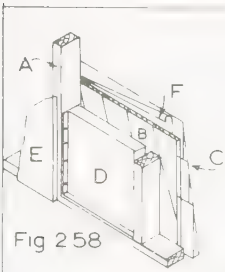


Fig 2 58

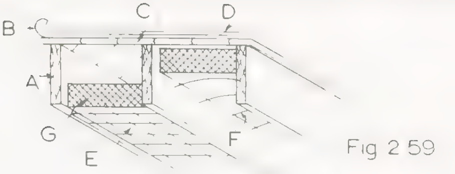


Fig 2 59

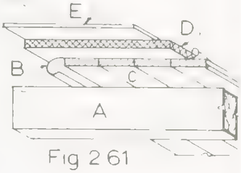


Fig 2 61

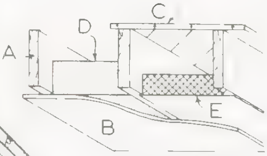


Fig. 2.60

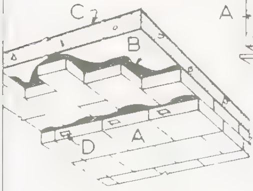


Fig 2 63

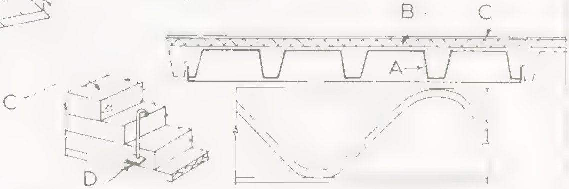


Fig 2 62

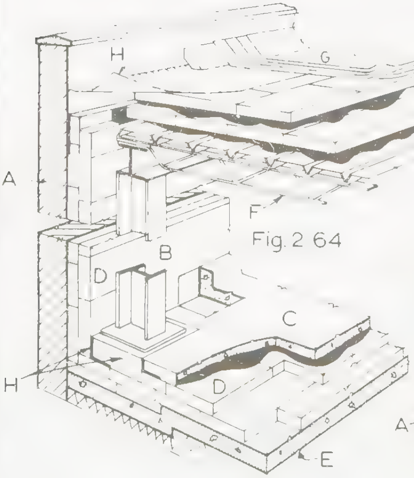


Fig. 2 64

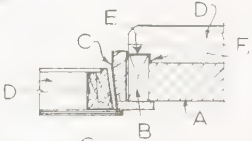


Fig. 2 66

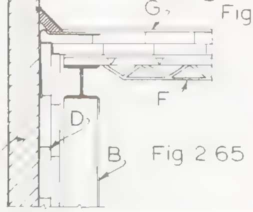


Fig 2 65

INSULATION

False ceilings

Figs. 2.67a to 2.67d Suspended fibreboard ceiling

- *A* 300 mm × 300 mm fibreboard t. & g. tiles 13 mm thick (other sizes also)
- *B* Aluminium U channels at 300 mm or 400 mm c/c
- *C* 38 mm × 12 mm metal channel at 1200 mm c/c
- *D* Metal fixing clip
- *E* Threaded rod hinges
- *F* Splice plate
- *G* Screw
- *H* No. 4 short 'pop' rivets

Fig. 2.68 Plastic laminated sheet steel tile

- *A* 600 mm × 600 mm plain or perforated lip-edge tiles
- *B* Supporting metal channel
- *C* Fixing clip
- *D* Metal spring tee section

Fig. 2.69 Suspended plasterboard ceiling

- *A* 10 mm or 13 mm plasterboard ceiling
- *B* Metal angle hanger supporting tee channel
- *C* Light tee section at 600 mm c/c
- *D* Metal wedge

Fig. 2.70a Detail to lighting panel, expanded metal and plaster

Fig. 2.70b Detail to lighting panel and other suspended ceiling

Fig. 2.70c Wall detail

Fig. 2.70d Lighting assembly

- *A* Angle cleat
- *B* 12 mm × 12 mm tie bar
- *C* 25 mm × 25 mm aluminium hanger
- *D* Aluminium arrow section 63 mm × 35 mm
- *H* Other types of ceiling
- *J* Wood ground for fixing
- *M* Polystyrene diffusing panel

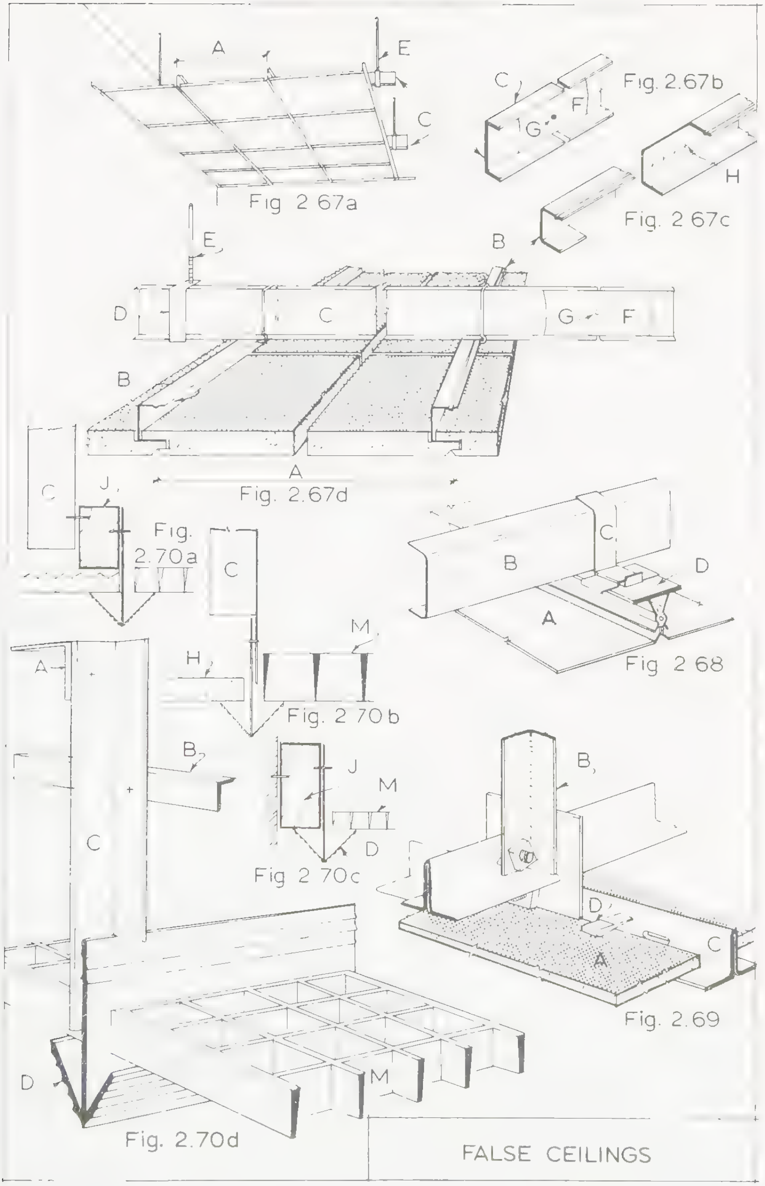


Fig 2 67a

Fig. 2.67b

Fig. 2 67c

Fig. 2.67d

Fig 2 68

Fig. 2.69

Fig. 2.70a

Fig. 2 70 b

Fig 2 70c

Fig. 2.70d

FALSE CEILINGS

CURTAIN TRACKS. An example of such provision can be seen in *B*, Fig. 2.71 where an aluminium channel has been incorporated during the plastering operation. The spring clip *C* is inserted later when the curtain track *A* is to be fitted. The track is about 25 mm deep and may be of brass or reinforced nylon. It is supplied in cut lengths up to 4 m or in coils of 38 m. The wheels are also of brass or nylon. Pelmet rails are also supplied if required.

Figure 2.72 shows a fluted aluminium rail with nylon gliders. The design is now very popular as it is quiet and dispenses with the need for pelmets. The track is obtainable in lengths up to 5 m. Some makers provide all-nylon rails and gliders, which come complete with cord sets for operating heavy curtains or those out of reach. Provision can also be made for extension brackets to hold a second track, which is useful where mesh curtains may be needed for privacy or to keep out flying insects. Curtain tracks may also be used around hospital beds or can be secured to ceilings to provide mosquito screens if required.

SUN-BLINDS. Although strictly an external fitment, these are dealt with here to group them with window coverings in general. The blind shown in Fig. 2.73 is a simple sturdy design which has been in use for many years. The action is simple; it is operated by a single cord and can be held at any angle according to the position of the sun. It is normally supplied with a spring in a tinned barrel roller but the spring can be omitted if the window is small. The fabric is waterproof and colour-fast.

The Dutch canopy shown in Fig. 2.74a is also very effective. It is simply constructed, provides sun protection, and is gay in appearance. It is made with either a metal frame with solid bronze hinges or with a good-quality hardwood frame with metal hinges. It is cord operated.

VENETIAN BLINDS. These have been in use for many years and are still popular, especially when made in gay colours with new materials. Figure 2.75 shows the principle of operation. The gearbox *A* is worm driven and is connected to a shaft *B* which turns the drums *C*. These travel horizontally as they turn, thus ensuring that the cord *D* is wound up evenly keeping the slats horizontal.

The type shown here, operated by a control rod, is suitable for high windows or where large blinds are needed. The ones for small windows are operated by cords only. These are usually made of Terylene, which will withstand a great deal of rough wear. The ladder webs *E* pass over the drums in a continuous loop and enable the slats *F* to be held by friction to any desired angle. The bottom rail (not shown) is usually of galvanized m.s. oval section, stove enamelled to match the slats. The heavy brackets *H* are supplied by the manufacturer according to the size of the blind. They may be either fixed as shown or plugged direct to the wall.

There is a newer type of blind, now much in vogue, which consists of vertical slats or louvres, vinyl impregnated, with attractive surface textures and a wide choice of colours. The draw action, controlled by polyester cords, permits the vanes to rotate from the closed position through 180 °.

FIXING OF IRONMONGERY. Fixing of fittings to masonry or concrete can now be effected easily and quickly without recourse to plugging of walls or drilling of the metal structure.

The speediest method of securing hardware is by use of a *cartridge* or *stud gun*, of which there are several makes, Fig. 6.14. The action is similar to that of a pistol; the firing pin strikes a percussion cap, and explodes a small charge which drives the fixing device into position. The latter may be a special nail, threaded stud, countersunk screw set, rivet, etc., and can be driven into steel, concrete, masonry, etc. The gun is fitted with various safety devices, and goggles are supplied to the operator. The explosive charge can be selected by using cartridges of varying power. The gun is portable, speedy, and accurate and can do most fixing jobs, but it has some drawbacks. It is not suitable for fixings near external angles or arrises and does not suit all types of concrete, e.g. the types with flint or pea gravel aggregate. Spare supplies of cartridges and fittings must always be available, particularly where these have to be imported. The cost too must be weighed against that of hand labour. There is no doubt, however, that they have many uses.

Rawlplugs. These have now become a household word, and the principle of inserting fibre plugs into drilled holes needs little introduction. When the masonry or rendering is soft, a better grip may be obtained by filling the hole with asbestos cement fibre, wetted and packed into the hole, after which the fixing can be done immediately.

For heavier work a wide range of proprietary structural fixings is available. In one type the main object is speedy fixing of bolts and studs in concrete without recourse to grouting. This is done in several ways, but usually by causing a sleeve or anchor to expand holding it firmly in position. Volume 3 shows several examples. Fixing to thin sheets is done by the use of bolts with toggles attached which pass through the hole and open in the cavity behind the sheet. Thin metal

Curtain rails and blinds

Fig. 2.71 Recessed curtain track
A Brass track 25 mm high
B Aluminium channel
C Spring clip
D Brass wheels

Fig. 2.72 Tracks for use without pelmet
A Fluted anodized aluminium track
B Nylon gliders

Fig. 2.73 Sun-blinds
A Plastic or cotton blind
B Metal rod stay
C Spring roller in box
D Casement window open
E Position of blind fully down

Figs. 2.74a and b Dutch canopy
A Striped sun-shade
B Hinged wood stays (or metal)
C Timber frame

Fig. 2.75 Venetian blind
A Worm and wheel reduction gearbox
B Drive shaft
C Travelling winding drums
D Terylene cord
E 25 X 13 mm terylene ladder web
F Aluminium alloy slats 50 mm wide
G Bracket for top fixing
H Angle bracket (can be plugged to wall)
K Control rod
L Extension rod for high windows

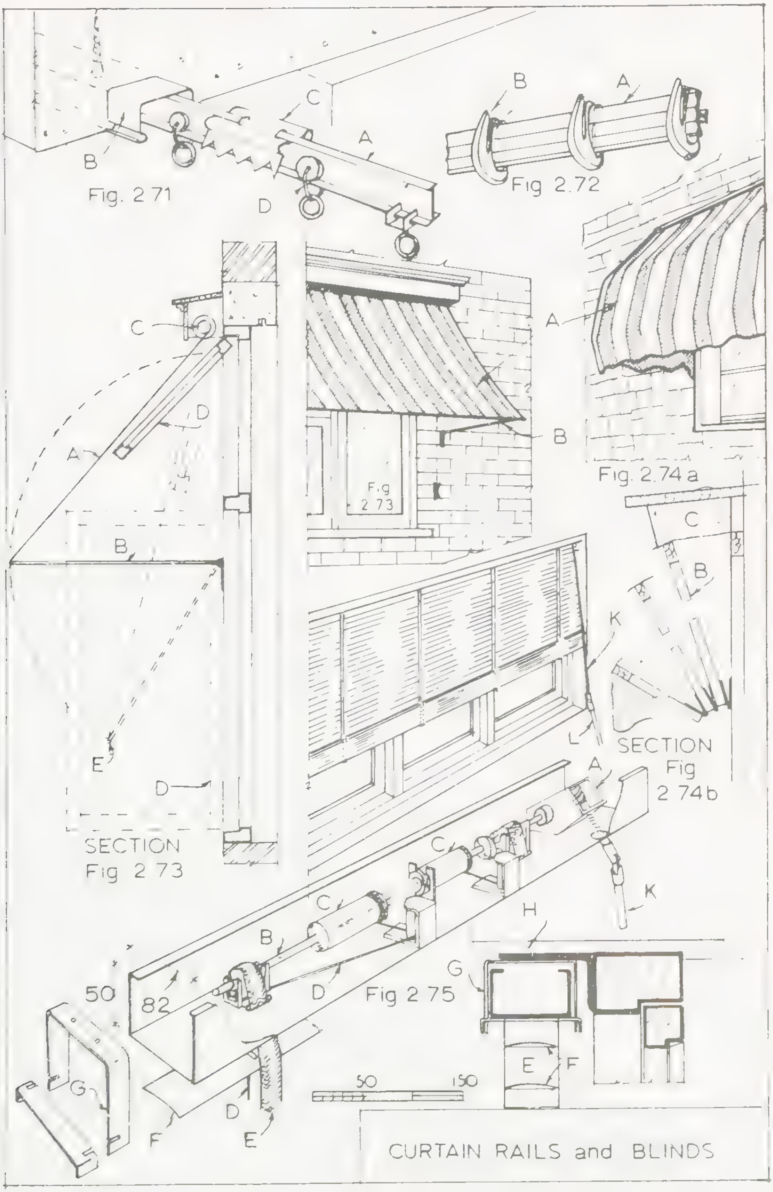


Fig. 2.71

Fig 2.72

Fig 2.73

SECTION Fig 2.73

Fig. 2.74 a

SECTION Fig 2.74b

Fig 2.75

CURTAIN RAILS and BLINDS

sheets may be joined by use of 'pop' rivets, Fig. 2.67c. Their use in fixing ironmongery, however, is rather limited.

Use is also made of asbestos cement supplied in block form. These inserts may be nailed to the formwork before the concrete is poured, thus providing a fixing ground which is superior to wood blocks. A variety of blocks are available to suit different types of fixture.

Plugging of masonry or concrete can be done by using either hand or power tools. Examples of power tools are given in Figs. 6.11 and 6.13. A refinement to these has been introduced whereby a drill can now be converted to a hammer if required.

DOOR CLOSERS. These are more or less essential in areas where air-conditioning is being used. They are also used in public buildings and districts subject to driving rain and sudden squalls.

Figure 2.76 shows a built-in floor spring, one of the many automatic closers available. This one is designed for swing doors, but single-action springs are also made. Floor springs are invisible, except for the plate, and are easily adjustable. They are sturdy, dependable, and easily fixed, but are rather expensive.

A cheaper and equally reliable type is the *overhead closer* shown in Fig. 2.77. This type is widely used, particularly where appearance is of secondary importance. Many refinements can be incorporated into these models, e.g. the spring power, closing speed, and latching action can all be separately adjusted. Other modifications are supplied including a hold-open arm with an automatic fusible link release in the event of fire.

Hospital-type closers can also be provided to keep the door open at any of three points: 10°, 40° 90°, or 140°. The closing action can also be delayed to enable slow moving traffic to pass without hindrance. Telephone booths and closet doors can also be checked to within 100 mm of closing to permit ventilation of the interior. The door can be completely closed at a touch.

Many modern forms of closer are available, e.g. those with streamlined surfaces for better appearance, concealed closers built into the head of the frame or top of the door, or simply built into the floor with the lever arm invisible when the door is closed. A simple type is shown in Fig. 2.78. This is cheap and rugged, but slams the door unless controlled by hand. The spring arm *A* can be disconnected by raising it vertically when it is not required.

WINDOW OPENING GEAR. This is essential for controlling numerous or inaccessible windows, and many varieties are available. It operates on the shaft and lever principle shown in Fig. 2.79. This may be extended to control any number of windows, the gear winch shown will operate up to 30 m run. Another type of window-opener functions by means of a portable rod with a hooked end which engages with a ring to drive a worm gear at window height. It is readily adaptable for use with glass louvres.

A further type of window gear is given in Fig. 2.80. This is operated by means of a multi-stranded steel cable spun to form a continuous helical rack which engages the winding gear wheel. It is flexible, neat in appearance, and can be coupled to junction boxes if desired. The system can also be electrically operated.

SHUTTERS AND GRILLES. Internal open-work rolling grilles and shutters have many uses in modern buildings. They are well suited to tropical work as they are light, trouble free, decorative, and can conform readily to architectural styles where screens are traditional. There are many types available in both wood and metal.

The grille shown in Fig. 2.81 is effective and is used in lounges of hotels, public bars, refreshment counters, shop fronts, etc., where security, appearance, and free air circulation are important. The nylon units *A* are threaded on to the aluminium rod *B*, which acts as a hinge enabling the grille to be raised through guides *E* and housed on the roller above. Where long lengths of grilles or shutters are needed, intermediate vertical guides may be introduced to divide the grille into sections. These can be removed once the grille is open, leaving an uninterrupted floor or counter space. Locks or bolts can be fitted to the channels *D* as required.

PAINTING

2.11 Introduction

Perhaps the most important object of internal painting is decorative—to improve the appearance of the building and make it harmonize with other features such as furnishings and fittings. Painting also protects materials from the atmosphere and helps to preserve them. This is particularly true of steelwork.

COST. The cost of painting is a big item in the building budget and must be weighed against the cost of more expensive but more permanent finishes such as decorative laminates. The latter frequently prove

Opening gear. Shutters

Fig. 2.76 Double action door closer
- *A* 300 mm approx.
- *B* 150 mm to 200 mm
- *C* 57 mm
- *D* Coil springs
- *E* Pivot
- *F* Shoe

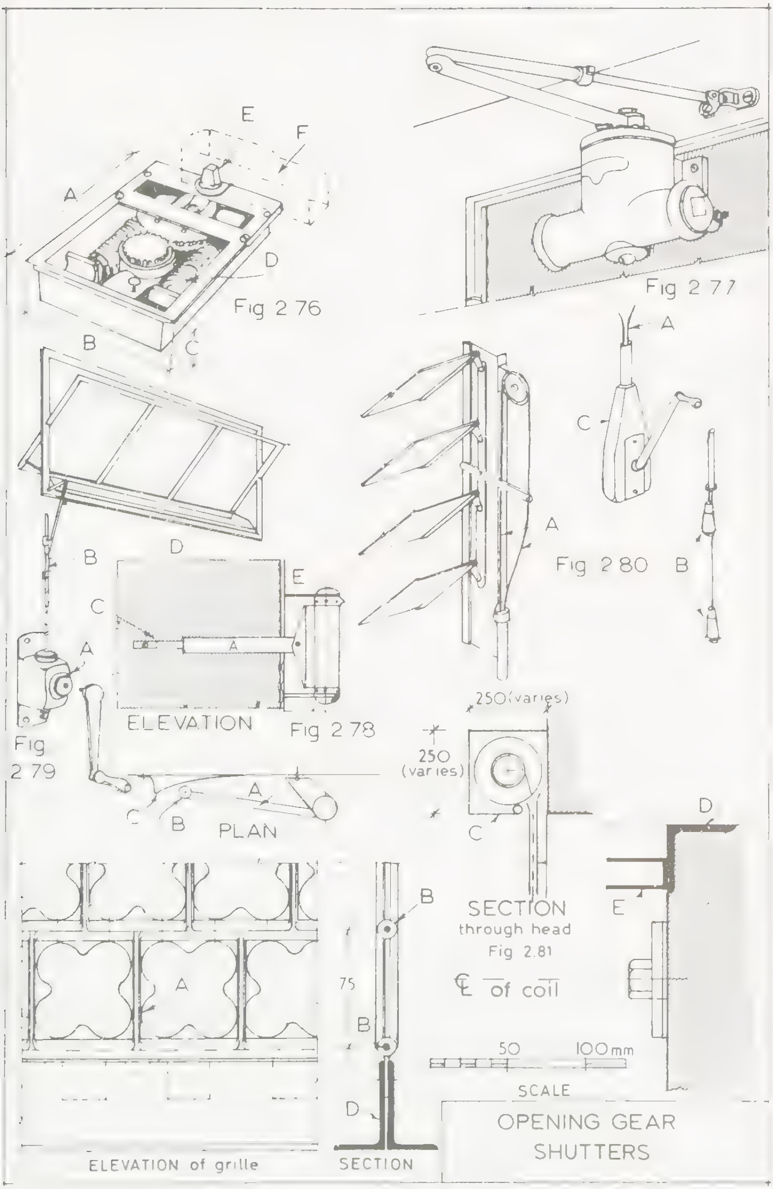
Fig. 2.77 Overhead door closer (old style)

Fig. 2.78 Door closer with adjunct spring
- *A* Swivel arm (detachable)
- *B* Brass pulley
- *C* Spring steel track
- *D* Door
- *E* Frame

Fig. 2.79 High window opening gear
- *A* Winding box
- *B* Adjustable shaft and lever gear

Fig. 2.80 Teleflex opening gear
- *A* Twin-cable operating louvres
- *B* Plastic pull handles for single vents
- *C* Geared winch for large installation

Fig. 2.81 Grille curtain
- *A* Nylon unit
- *B* Aluminium hinge rod
- *C* Hood to encase roller (if required)
- *D* 63 mm × 39 mm × 3 mm aluminium alloy angle
- *E* Metal guides



OPENING GEAR
SHUTTERS

cheaper in the long run but cannot, of course, be changed at the time of redecoration with a new colour scheme, which is why painting has remained so much in favour today.

Only good quality paints should be used; cheap paints, which deteriorate quickly, can cost more eventually and do not look so attractive. This particularly applies to finishes exposed to strong sunlight or salt-laden or industrial atmospheres.

2.12 Preparation

Good preparation before painting begins is very important; this can vary according to conditions the paintwork will have to withstand. Sun, water, sea air, and industrial smoke can all affect surfaces, especially where these are open to the atmosphere. Steelwork, for instance, may require only brushing or scraping if not subjected to exposure, otherwise it may need chipping or grit blasting. Internal walls of hard gypsum plasters need rubbing down with sandpaper, especially if a gloss finish is needed, and the woodwork may need stopping of cracks, joints, and nail holes or fine sandpapering. Knotting is not usually required for hardwood.

COLOUR. Today more attention is paid to colour than hitherto, with a tendency towards brighter decoration using pastel shades, particularly in industrial and commercial interiors. Workshops are now frequently decorated, and fittings and equipment, including machines and floors with little traffic, are included in colour schemes.

Quiet shades also have their uses as in libraries, religious retreats, convalescent homes, or where colour should not distract but provide the restful background expected in such buildings. The choice is often governed by taste, cost, availability, or a combination of these factors.

PROTECTION. Protection and decoration are the two important functions of painting. In interior work, particularly walls and ceilings, the decorative function may be considered more important, even though the walls may have to withstand washing.

The protective value of paint normally increases with its thickness, i.e. the number of coats applied. Gloss finish on plaster will normally require three coats but emulsion paint generally needs only two.

Where chemical attack can occur special paints may now be bought based on chlorinated rubber or epoxy resins, and these have proved effective. The former have good resistance to acid whilst the latter have strong resistance to alkalis and solvents.

Surface heat can often be a problem not only from tropical sun but also from manufacturing processes. Most good-quality paints will stand heat up to 90 °C but with some discoloration. Above this temperature it is usual to use aluminium paint, although this will need frequent renewal.

Humidity is of itself not harmful, although it is conducive to erosion, especially on absorbent materials and steelwork. In some instances, particularly in industries where high humidity is encountered, *saponification* and discoloration is caused, especially to surfaces containing alkalis. Normally full gloss paint provides the best protection against humidity.

Mould. This can be a serious problem in some parts of the tropics, resulting in a growth of unsightly fungus which is difficult to remove. Treatment with fungicidal solution of surfaces already painted can effect some improvement. Fungicidal primers and undercoats as well as finishing coats, however, are advised where severe conditions are encountered. The mould or fungi normally spreads by means of airborne spores or from adjacent areas which are infected. For maximum protection, this areas should also be treated if this is at all possible.

Food storage. Sometimes foodstuffs exposed to odours of new paint can become contaminated, and special low-odour paints may be needed. Rules on this score in food-processing factories can be very strict, and it is advisable to enquire about the toxicity and tainting factor of paints to be used near foodstuffs from the manufacturers concerned.

TIME. The time available for painting is rarely enough for a really satisfactory finish, especially with maintenance work. Frequently the painting of work-places is carried out after working hours, at weekends, or during holiday periods. Such a programme very often allows little time for adequate preparation. In an effort to overcome this problem, work is sometimes carried out intermittently, say, over several weeks. This is rarely satisfactory as contamination of surfaces can take place between successive coats of paint. A solution may be arrived at by careful planning, perhaps enabling some work to be done during working hours, and by the use of quick-drying paints.

2.13 Types of paint

The variety of paints available is now extremely wide and only a small selection will be given here.

Red lead metal primer. This is used mainly for iron and steel. It provides very good protection, especially where steel has to stand for long periods before further paint is applied.

Chromate-based metal primers are also widely used and are claimed to be similar in performance to red lead metal primers. Additionally, they may be used for priming aluminium and its alloys.

Calcium plumbate. This is designed for direct application to new galvanized iron. It may also be used for priming wood.

Aluminium primer. This can be used for all kinds of wood. It may also be used as a sealer for previously creosoted or bitumen-coated surfaces.

Wood primer. This is normally of a consistency to suit softwood. For hardwood it may need to be thinned to assist penetration. This is done by adding turpentine or white spirit to the primer as required.

Alkali-resisting primer is for use on plaster, concrete, asbestos, cement, etc. It is particularly suitable for cement rendering, especially when painting has to be carried out as soon as the rendering has been completed.

Gloss finish. This is very widely used and obtainable in many varieties and colours. Some brands require a double coat of gloss finish for maximum durability.

Undercoat. It is always advisable to use the recommended undercoat to match the gloss finish. In some countries, however, the undercoat is frequently omitted altogether, resulting in inferior and poor-quality work. Some manufacturers now supply a multi-purpose paint which is claimed to have the qualities of multi-coat paints, but which is applied in a single coat.

Emulsion water-thinned paints are now widely used throughout the world. They may be applied to brickwork, plaster, cement, wall-board, plasterboard, over old paint after proper preparation, or even wallpaper. They are not suitable for direct application to wood surfaces.

SPECIAL PAINTS. *Quick-drying enamel* is normally used for repainting plant and machinery under interior conditions.

Floor paint. This is suitable for concrete, stone, or granolithic floors and usually gives a semi-gloss finish. It is fairly resistant to wear and abrasion, and is supplied in a range of colours.

Aluminium paint is used on wood or metal and can resist high temperatures if desired.

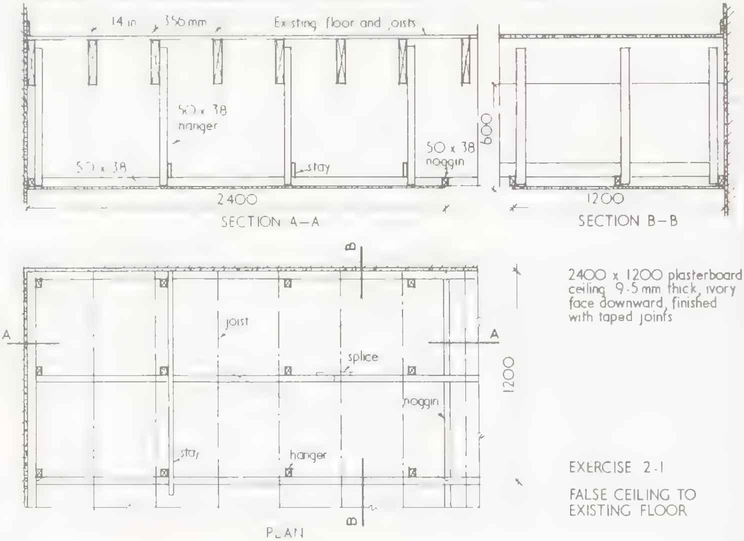
Varnish. Pale colour medium oil varnish is very suitable for interior work not exposed to sunlight.

Knotting. This is used for the treatment of knots, usually in softwood. It is not widely used in tropical countries.

For further reference to paints and painting see Volume 3.

2.14 Spread

The spreading power of paints depends on many factors including the type and preparation of the surface, the quality of the paint, the number of coats, and the conditions under which it is applied. As a very rough guide, the spreading capacity ranges between 11 and 15 m^2 per litre.

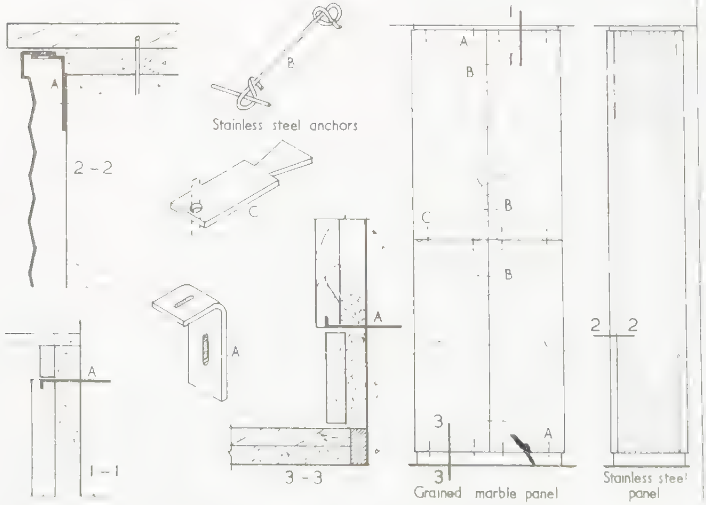


2400 x 1200 plasterboard ceiling 9.5 mm thick, ivory face downward, finished with taped joints

EXERCISE 2-1

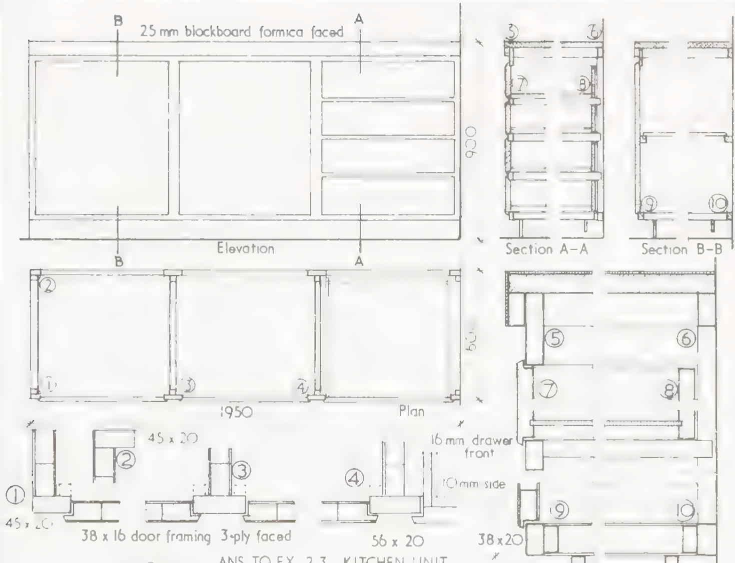
FALSE CEILING TO EXISTING FLOOR

AN ANSWER –

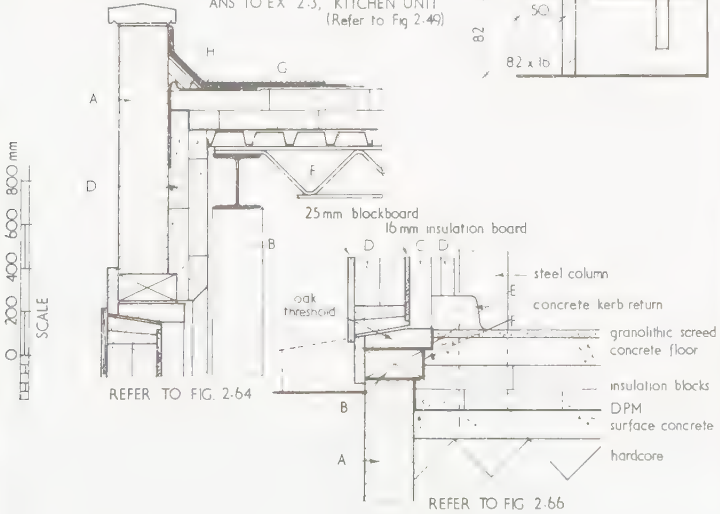


ANS TO EXERCISE 2.2

MARBLE PANEL ANCHORED TO CONCRETE



ANS TO EX 2.3, KITCHEN UNIT
(Refer to Fig 2.49)



ANSWER TO EXERCISE 2.4, COLD STORAGE CHAMBER

3 | Services

3.1 Introduction

Modern building is very complex in its servicing requirements. The simplest structure of a permanent nature usually has some built-in amenities, such as water and/or electricity, but rising standards of living now tend to demand more up to date installations involving specialists with new skills.

The layman will accept electric light and power, telephones, radios, hot water, air-conditioning, refrigeration, lifts, etc., as a matter of course without knowing how they work. But whilst it is not necessary for the architect or builder to have a detailed knowledge of service installations and their maintenance, it is essential that he should appreciate the broad principles of their operation, because they constitute part of the structure.

This chapter then will deal only with the standard equipment which may be found in tropical buildings of today. Hospitals, factories, universities, and laboratories often have their own installations, which will not be discussed here. It is hoped that the reader will have an opportunity of continuing further studies in this wide field.

VENTILATION

3.2 Natural ventilation

Natural ventilation in tropical areas has already been touched upon in Volume 1. The necessity for correct orientation, cross ventilation, overhanging eaves, and perforated walls to provide a satisfactory microclimate has been discussed in previous chapters, as have sizes and shapes, louvres and prevailing winds.

In many instances such provisions can be insufficient and further means have to be found to improve comfort within enclosed spaces. One way of achieving this is by the use of specially designed ventilators in walls and roofs. These involve no mechanical plant, running costs, ducts, or air distribution systems which can sometimes prove expensive and difficult to install.

Roof ventilation is the most popular means of improving air circulation, and there are many types of natural ventilator. A simple and widely-used type is shown in Fig. 3.5. This is known as the 'Colt Multifunctional Ventilator' and is used in single-storey factory buildings where the fumes, steam, or dust produced are not excessive. This ventilator depends mainly for effect on the force of the wind and also on the difference between the inside and outside temperature. The cowls are normally placed on the ridge but may be built into the roof slope as shown in Fig. 3.6.

The models best suited to the purpose and their spacing along the roof can be determined from makers' data books; the exhaust rate of the air depends on the height above ground, difference in temperature, wind velocity, etc. The extractor mounted between patent glazing bars in Fig. 3.6 is known as the 'constant flow' model and will extract a steady volume of air despite variations in wind speed and temperature. An improved type of automatic control can not only direct air downward, giving some relief to occupants below, but can also open automatically, as in Fig. 3.5*B*, in case of fire. Models for exhaust applications or air supply are made by leading firms for industrial, commercial, office, or residential use.

Frequently lighting and ventilation units are combined in a single piece of equipment. The adjustable glass louvre is an obvious example of this. Flat roofs also have rooflight ventilators, and one such type is shown in Fig. 3.1. This is mounted on a concrete kerb, Fig. 3.3, and has fixed louvre vents with 'hit-and-miss' shutters. It is made either square, rectangular, or circular and is supplied in either aluminium or galvanized steel. The dome may be of glass, acrylic, wire laminate P.V.C., or laminated glass fibre and is fully weathertight. Security fittings are supplied to minimize the possibility of illegal entry. Louvres can be opened by long-arm or remote-control gear, if specified.

Another type of controllable louvre is shown in Fig. 3.4. This is incorporated within the ventilator upstand, ensuring a flush face when the louvres are open or shut. A single operator, *R*, enables all four leaves to move simultaneously. Bird-guards and fly-screens can also be supplied on request.

Air-flow. Before roof ventilation can be decided upon, it is necessary to study the patterns of air-flow for the district where they are to be applied. Those responsible for design will need to learn something of this subject, particularly where makers' data books are not available or applicable. Charts termed *nomograms*, which give air extraction rates for certain conditions, are often issued by suppliers and also by some official government sources. The subject is a wide one and cannot be dealt with here. Suffice it to say that normal conditions demand

Continued on page 76

Natural ventilation

Fig. 3.1 Natural ventilation
- *A* Glass dome
- *B* Acrylic wire laminate, PVC, or glass fibre
- *C* Sealer
- *D* Dome clip
- *E* Wood plugs
- *F* Hit-and-miss shutters
- *G* Fixed louvres

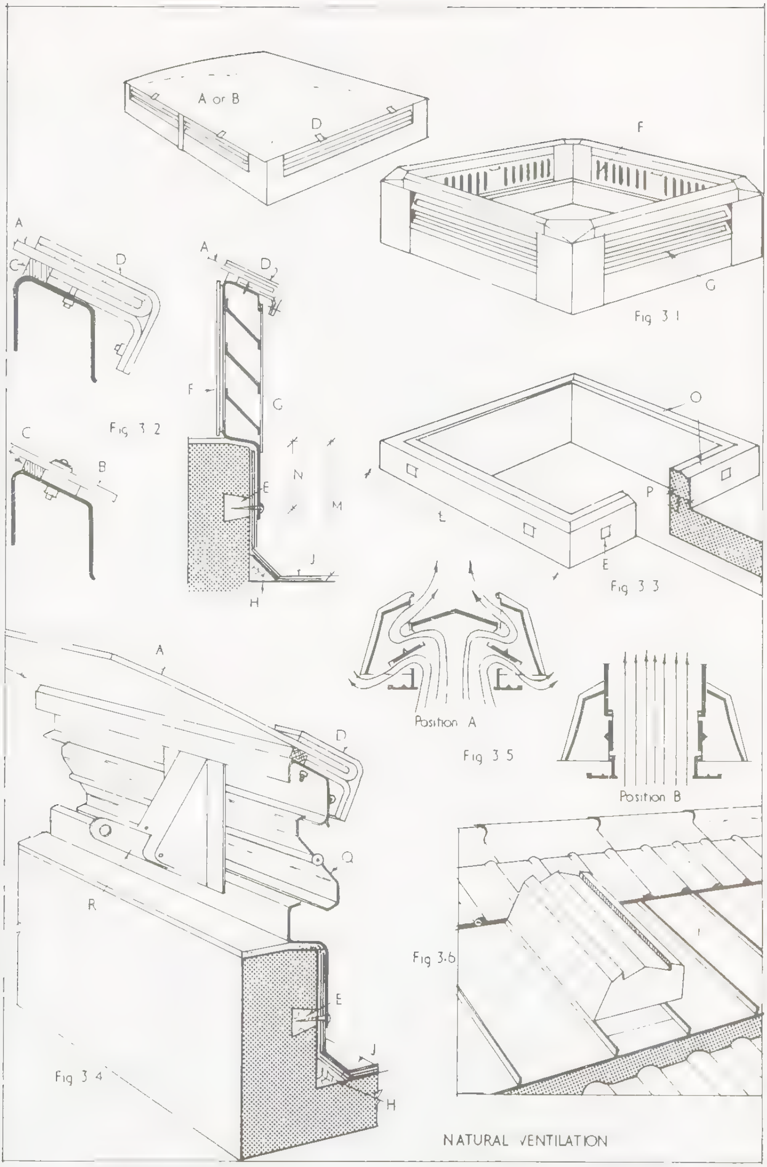
Fig. 3.2 Section through fixed louvre
- *H* Timber fillet
- *J* Roof finish

Fig. 3.3 Sketch of concrete kerb
- *L* Size 523 mm × 533 mm to 2362 mm × 1143 mm
- *M* 150 mm minimum
- *N* 75 mm
- *O* Kerb top chamfer 10° × 50 mm wide
- *P* 70 mm min. including roof finish.

Fig. 3.4 Sketch of adjustable louvres
- *Q* Adjustable steel louvre
- *R* Operator (controls all louvres)

Fig. 3.5 Colt multifunctional ventilator
- *A* Partly open to suit climatic conditions
- *B* Clear opening ventilation. Flaps open automatically in case of fire

Fig. 3.6 Sketch of Colt extractor ventilator



NATURAL VENTILATION

Mechanical ventilation

Fig. 3.7 Mechanical air extractor (flat roof)
A 775 mm to 1520 mm
B 375 mm to 820 mm
C 560 mm to 1100 mm
D 530 mm to 812 mm
E 250 mm to 457 mm
L Bird-guards (optional)
M Heat conservation shutters (optional)

Fig. 3.8 Detail for flat roof mounting
J Roof finishing
N Casing
O 75 mm × 50 mm hardwood sill
P Diaphragm plate screwed to sill

Fig. 3.9 Sketch of extractor on sloping roof
Q Hinged cover
R Asbestos ridge

Fig. 3.10 Plan of diaphragm plate
S Main roof purlins
T 50 mm × 50 mm steel angle trimmer

Figs. 3.11 and 3.12 Sections through diaphragm plate and mounting (Fig. 3.10)
U U-hook bolts
V Adaptor bolts holding diaphragm *P*
W Cover flashing

Fig. 3.13 Sketch of starter regulator
A Single-phrase type starter: size 267 mm × 114 mm × 133 mm high
B Red neon indicator light
C Fast, medium, slow control. (Three-phase regulators also obtainable)

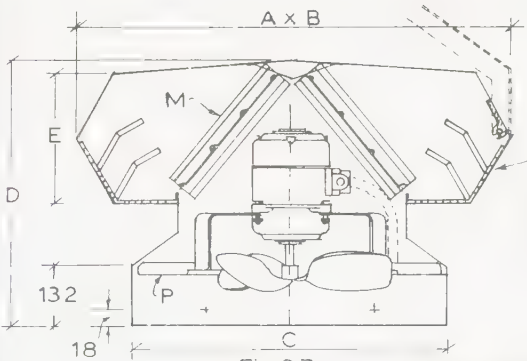


Fig. 3.7

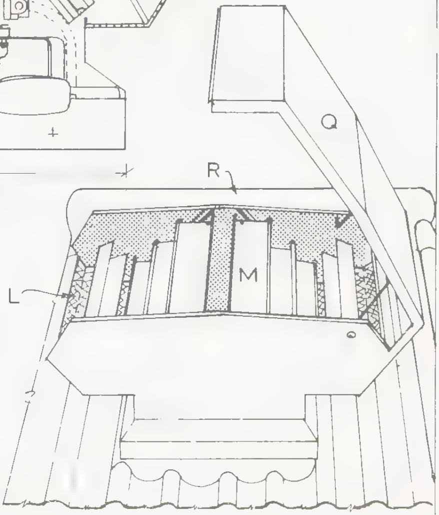


Fig 3.9

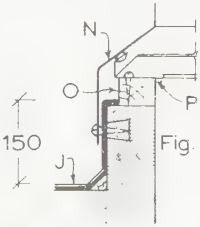


Fig. 3.8

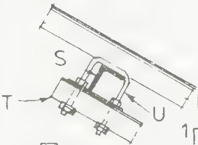


Fig. 3.11

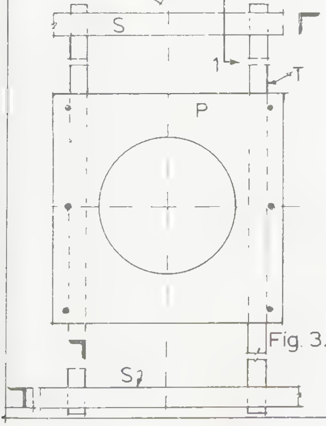


Fig. 3.10

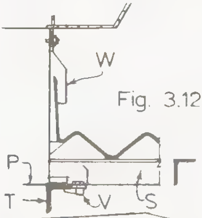


Fig. 3.12

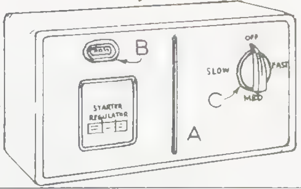


Fig. 3.13

MECHANICAL VENTILATION

between two and three changes of air per hour with as little air 'bunching' and as few dormant pockets of air as possible.

Exercise 3.1 Redraw the sketch of the louvre given in Fig. 3.4 in any suitable method of projection. Insert, however, fixed louvres with 'hit-and-miss' vents as shown in Figs. 3.1 and 3.2.

3.3 Mechanical ventilation

Air movement and extraction by natural means are sometimes insufficient, particularly in tropical conditions where rain and dust have to be excluded, thus making ventilation difficult. In such cases mechanical ventilation has to be installed. The most widely-used method for this purpose is the fan. The smallest and most portable model for moving air is the table fan, though telescopic floor stands are also popular. Some fans have a press-button control which enables them to be stopped when pointing in any direction or their speed to be varied at will. Their use, however, is chiefly limited to domestic and office work, although they have many individual applications in industry.

Ceiling fans are also in wide use in tropical countries, and life without them would be very unpleasant in some areas. They are quick and easy to install, require nothing beyond a 13 A control switch, and need little maintenance. They are available in many sizes. When these fans are new they are silent and efficient in operation, and speed can be controlled to within fine limits. Unfortunately they are frequently abused by neglect and, with lack of periodic maintenance, become noisy, which can be disturbing in assembly halls or lecture theatres or other places where silence is essential. They can also be troublesome because of air movement which, when confined to a small area, often causes too strong a draught for those under the fan. Ceiling fans also tend to blow papers about; and they do not have any effect on humidity. There is no doubt, however, that their advantages far outweigh their disadvantages.

ROOF EXTRACTOR UNITS. A popular and effective form of ventilation, where natural ventilation is not sufficient, is an electric fan inserted into the type of ventilator described in Fig. 3.1. Electric fans can be supplied in a range of types, sizes, and speed ratings to meet most requirements. Sizes vary from 300 mm to 600 mm, and suit dome lights up to 750 mm square. These fans have a free air intake capacity of up to 8850 m^3/h. It is difficult to generalize, but a rough minimum estimate of normal needs would be about 28 m^3/h per person. Calculation of fan sizes and their distribution can be obtained from suppliers' data sheets once the basic requirements are known.

A further type of powered roof extractor is shown in Fig. 3.7. This is designed for industrial buildings where high exhaust capacities are required. It is made in six sizes from 230 mm to 750 mm nominal size fan with exhaust capacities from 12 to 245 m^3/min. Speed regulators are available for single- and three-phase motors. These will operate in an ambient temperature of 40 °C, which is suitable for most countries when acting at roof level.

Should it be necessary to conserve heat temperatures sometimes drop sharply at night this model can be fitted with heat conservation shutters if desired. These automatically close when the fan is switched off, and their use is optional. The extractor is suitable for mounting on all types of flat or sloping roof. Figure 3.9 shows a sketch of the extractor fitted to a corrugated asbestos or metal roof. The top has a hinged lid giving external access for maintenance. Figure 3.11 and 3.12 show sections through the diaphragm plate and mounting, Fig. 3.10

WALL EXTRACTOR UNITS. Mechanical extraction of air frequently becomes necessary where fumes or odours from kitchens, internal lavatories, etc., have to be removed quickly. It is also desirable in cinemas, lecture theatres, or enclosed spaces where natural ventilation is not feasible because of the penetration of light or noise through open windows.

When used to improve cross ventilation, mechanical extractors should, where possible, be placed in walls opposite doors or windows. The siting of extractor fans should, in any case, be arranged in such a way as to avoid short circuiting of air resulting from extractors being located too near the ingress point.

Extractor fans are now made for a variety of purposes. They may be fitted into canopies or hoods over cooking ranges, in individual wash-rooms and w.c.s, or in windows of small kitchens, laboratories, or offices. Sometimes they are mounted outside the building and extract air through a duct in the wall. One type used for ventilating internal w.c.s, has polythene tubing which takes the foul air from a special collector at the back of the w.c. pan; other types have two-way fans or balanced flues which, on extracting stale air, supply fresh air in its place. Such refinements, however, are not usual in warm countries.

MECHANICAL AIR-CONTROL. As countries become more industrialized so the need for improved air-control increases. This is particularly true of factories and workshops where clean air is essential, e.g. food-preparation areas or instrument assembly shops. In such cases the

Continued on page 82

Air conditioning

Fig. 3.14 Customer-designed air conditioning system

A Air intake
B Filter
C Freon compressor and condenser
D Cooling coil
E Fan motor
F V-belt drive
G Fan
H Conditioned air supply
J Return air
K Dampers

Fig. 3.15 Chilled water supply system

A Evaporative condensers
B Refrigeration compressor
C Water chillers
D Water pump
E Chilled water lines
F To air handling units

Fig. 3.16 Packaged air conditioner

A Four-way adjustable louvre (or to ducts)
B OFF-AIR-COOL switch, thermostat
C Adjustable speed fan
D Rubber-mounted bearing
E Fan motor
F Evaporator
G Permanent cleanable aluminium air filters
H Liquid line sight glass
J Liquid filter-drier
K Pressure-equalized thermostatic valve
L Fresh air opening at back
M High-low pressure cut-out
N Vertical condenser
O Water connexions
P Compressor
Q Hot gas silencer

Fig. 3.17 Cabinet type precipitron

A Cold water supply
B Washable adhesive supply
C Collector cell

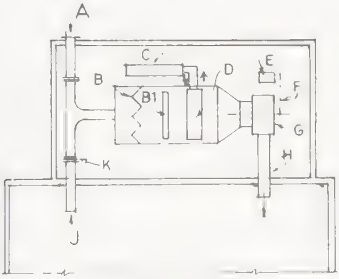


Fig 3.14

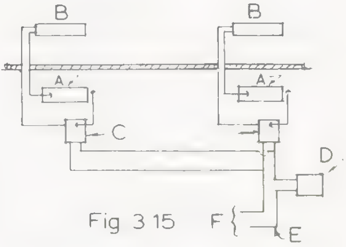


Fig 3 15

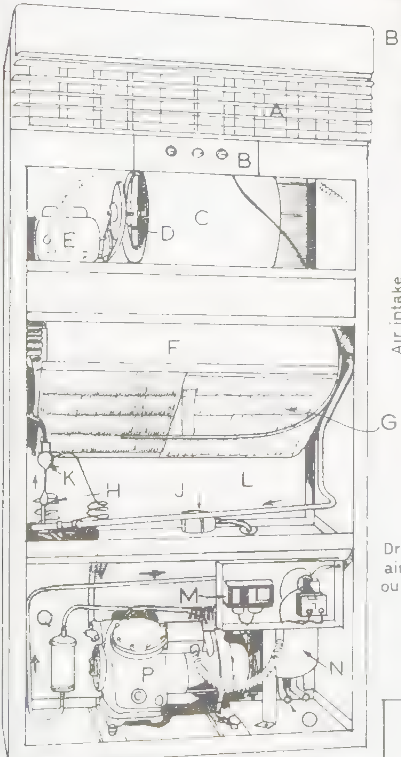


Fig. 3.16

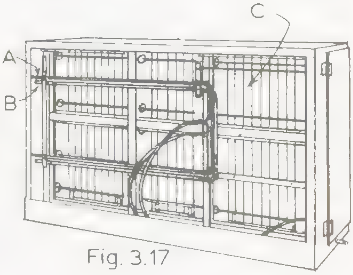


Fig. 3.17

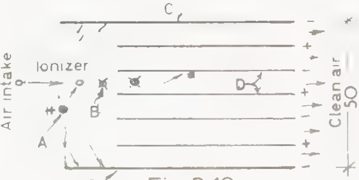


Fig. 3.18

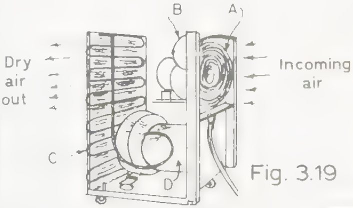


Fig. 3.19

AIR CONDITIONING

Fig. 3.18 Enlarged plan of one fin
A Ionizing wire
B Charged dust particle
C Earthed extended plate
D Alternate earthed and insulated plates

Fig. 3.19 Dehumidifier (without cabinet)
A Air drying coil
B Air circulating fan
C Refrigerant condenser and grille
D Sealed refrigerating unit

Fig. 3.20 Centrifugal liquid chiller. Section
A Compressor
B Eliminators
C Distributor
D Cooler
E Condenser
F Condenser sump
G Float valve

Fig. 3.21 Liquid chiller (cut-away sketch)
A_1 Inlet guide vanes
A_2 Impeller
A_3 Compressor motor
H Oil sump
J Water box

Fig. 3.22a Unit ventilator
A Cooling element
B Face and by-pass damper
C Ramp
D Access panel
E Drain pan
F Filter
G Outdoor intake louvre
H Fan and housing
J Outdoor damper
K Indoor damper
L Discharge grille

Fig. 3.22b Damper position. Morning cool-down

Fig. 3.22c Normal position

Fig. 3.22d Night purging position

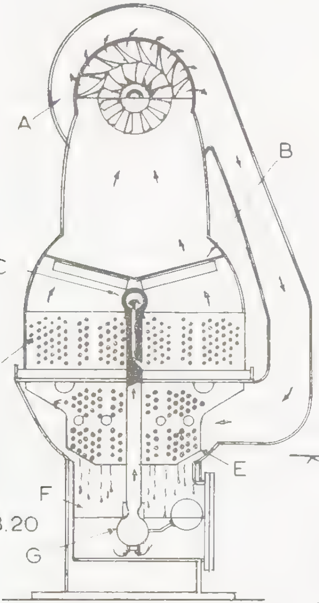


Fig 3.20

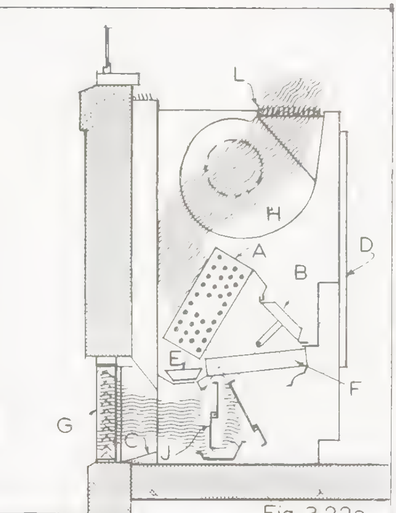


Fig 3.22a

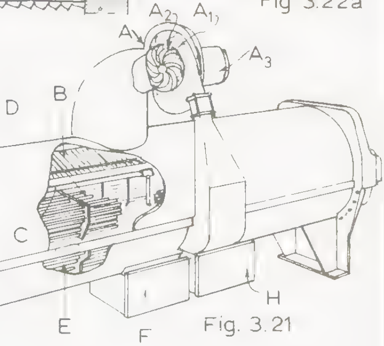


Fig. 3.21

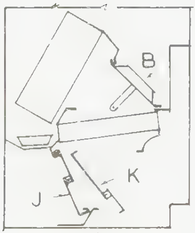


Fig. 3.22b

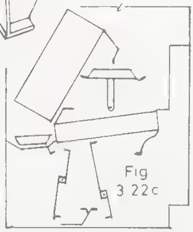


Fig 3 22c

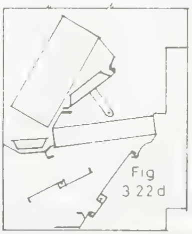


Fig 3 22d

AIR CONDITIONING

ingress of air is carefully controlled. This is done by passing all incoming air through filters and air washers. These processes will be described more fully under 'Air-conditioning'. Further examples of ventilation methods are given in Volume 3.

NATURAL LIGHTING

3.4 Introduction

Natural lighting has now come to be considered an essential part of the design of building. Although it cannot strictly be regarded as a service, it is appropriate that it should be considered here.

Good-quality lighting in buildings may be said to depend on contrast, i.e. variation between light and dark, without glare. Proper lighting helps occupants to see and recognize objects with the minimum of eye-strain, and the better the light the easier it is to work. The type of light must also be agreeable and this quality varies according to the user. Older people usually need more light than the young, and, even within the same age group, some people need more than others. Good lighting also means even lighting, i.e. the avoidance of sharp shadows which can cause eye fatigue. This, however, must not be confused with shadowless artificial lighting, once very popular but now out of favour.

DAYLIGHTING. Daylight is visible radiant energy from the sun and is measured in lumens. The base unit of luminous intensity is known as a candela (cd), a lumen being a unit of luminous flux emitted by a candela within a solid angle of one steradian. The unit of illumination equal to one lumen per square metre is known as a lux (*lx*).

'Sky' and 'daylight' factors are now frequently used in computing the level of daylight at any point in a room. The *sky factor* is dependent upon the outdoor level of light from an unobstructed sky. It is not an exact method of calculating daylight, because reflected light from surrounding surfaces can cause it to vary. The brightness of the sky is also not uniform. Solar radiation, i.e. the amount of heat radiated from an exposed surface, varies greatly with different materials and this can also affect the sky factor.

The *daylight factor* is more accurate; this takes into consideration both the direct and indirect light entering a room. It is expressed as the ratio of light in the room to the light of the unobstructed sky. A number of plotting instruments, diagrams, nomograms, meters, and other devices now exist for determining the daylight factor. Full information on the subject may be obtained from B.R.E., England and Australia where much experimental work has been carried out.

An important factor in visual comfort is *luminance* or brightness, which is a measure of the light reflected from surfaces. Any surface struck by light rays emits brightness, which is measured in lumens/m^2 of surface illumination. Brightness depends on the percentage of light which any surface reflects; the higher the reflection factor the greater the light from the surrounding area outside the building. The ratio of the luminance of an object to its surroundings has to be carefully balanced in order to provide the right conditions for comfortable vision. Excessive luminance ratios may result in glare.

Glare. There are a number of types of glare: disability glare, discomfort glare, and reflected glare. Many factors contribute to it: windows viewed against a bright sky, high luminance in the field of vision, size and source of light (small windows increase glare), and reflected light from shiny objects are some examples. The design and construction of buildings, particularly in the tropics, and their finish both internally and externally must be influenced by the light intensity of the surroundings. Normally, large areas of fenestration or luminous ceilings make for a glare-free environment.

Much work has now been carried out in this field. Many authorities in developed countries have laid down recommended illumination levels in lumen/m^2 for different establishments. These standards could form a good guide for areas where daylight factors have to be calculated from first principles.

COLOUR. One of the most important factors in determining interior lighting conditions is the use of colour. In the tropics blues and greens are often used because they produce a feeling of coolness, while reds and oranges are avoided, unless they are needed to produce sharp contrasts or to focus attention. Strictly speaking, the internal colour scheme of rooms should be decided before daylight calculations are made, but this may not always be possible.

LIGHTING NEEDS. In order to arrive at an assessment of the level of lighting required, consideration must be given to the location and orientation of windows, external surroundings, sun-control devices, and the type of glass used. The last of these is not usually of prime importance particularly if louvres are used. The placing of windows is important; high windows admit more light than lower ones; tall windows also admit light further into the room, but increase the tendency to glare. Horizontal baffles are now frequently inserted above windows either inside or out in order to reduce glare, see Volume 1.

In order to assist in the design of buildings, models are sometimes placed beneath an artificial 'sky'. By this means the intensity of light entering the room can be determined by varying the lighting in the 'sky' to simulate actual conditions. A good 'sky' can produce a light varying in brightness from horizon to zenith which is normally where the sky is brightest.

Ceiling heights can also affect lighting; the higher the ceiling the greater the illumination. Roof overhang, too, plays an important part in lighting. Light intensity will vary according to the amount of overhang and its height above the window. The colour of the overhang soffit is not quite so important, but a sharp contrast between the sky and the window surroundings should be avoided.

ARTIFICIAL LIGHTING

3.5 Introduction

A good deal of what has been said about natural lighting applies equally to artificial lighting. In both forms it is essential that certain basic factors are observed and provided for. In tropical countries with strong natural light the design of indoor lighting is not always as important as it is in more temperate zones where the natural light is weaker and where it is more likely that complex industrial operations will need to be performed, which could prove impossible without well-designed lighting. Whatever the conditions, it is necessary that the standard of illumination should be high enough to allow the eyes to function efficiently, whether at work or leisure.

The level of illumination varies, of course, according to the task. Concentrated or exacting tasks usually need more light. The levels of artificial lighting needed for many interiors are laid down in various Codes.

Determination of the illumination level

A simple rule which may be used in the design of small buildings

$$\text{is } \frac{lm}{A} = lx$$

where lm = lumens produced by lamps

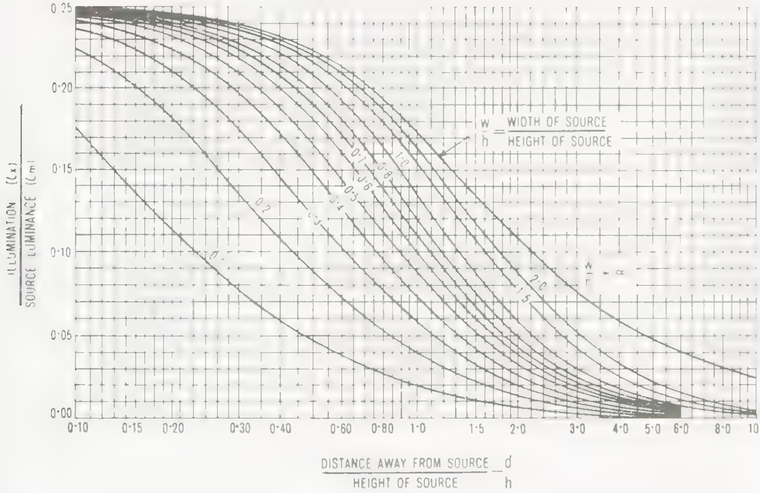
A = area under consideration

$$lx = \text{level of illumination expressed in lumen/m}^2$$

Light meters may be used for checking the illumination at any given point. The above rule, however, is very arbitrary and does not allow for maintenance or other factors.

Many manufacturers of lighting equipment have excellent charts and formulae from which any level of illumination can be determined.

GRAPH 1



One such chart is shown in the above graph. This may be used for artificial or natural lighting. An example of its use is as follows: suppose it is required to find the illumination at a point in a vertical plane parallel to a window size 3 m × 1·5 m high and 3 m away from the source;

assume the sky luminance to be 10 000 *l*x;

let w = width of window
h = height of window
d = distance from window

$$\text{then } \frac{w}{h} = 2 \text{ and } \frac{d}{h} = 2.$$

The $\frac{w}{h} = 2$ curve cuts the $\frac{d}{h} = 2$ ordinate where the value of that ordinate is 0.086. Hence the vertical illumination is

$$10\,000 \times 0{\cdot}086 = 860\ lx.$$

Glare. A good level of illumination will be effective only if there is no glare. This is usually caused by excessive luminance contrast, not only from a dazzling light source but also by reflection from shiny or highly-polished surfaces. Even slight glare can sometimes be disagreeable.

Luminance or glare meters can be used to determine the glare likely to be encountered at any point. Whilst excessive luminance can be troublesome, too little can also be disadvantageous by removing all highlights and shadow which can provide a pleasant contrast.

INCANDESCENT LAMPS. The type of lighting needed will depend on the purpose for which it is to be used. The range of luminaires is very wide. For interior lighting there are two main categories, viz. incandescent and fluorescent.

Incandescent luminaires are made for many different purposes, e.g. photography, floodlighting, rough service, reflection lamps for localized application, candle lamps, display lamps, etc. They are also made in a range of voltages and wattages and, where necessary, with filaments and gas filling designed for special purposes. Miners' lamps, for instance, may be filled with krypton instead of the less costly argon and/or nitrogen as this is much more efficient at low voltages when the power supply is in the form of batteries.

Full lists of lighting and other fittings are given in makers' handbooks and catalogues. For normal everyday use, however, the popular type is the pearl bulb supplied in voltages from 100 V to 250 V and from 25 W to 150 W. Popular sizes are 40 W to 100 W.

Disadvantages. In the tropics incandescent luminaires give rise to problems not usually encountered elsewhere. For instance, in positions exposed to high winds hanging flexes can quickly damage pendant fittings. They should also not be hung internally near ceiling fans a common fault in many buildings.

Enclosed light shades also give rise to problems. First, flying insects attracted by the light find their way into the inverted bowls at ceiling level necessitating removal and cleaning at frequent intervals; secondly, the clips or screws holding the shade are not always satisfactory, particularly in humid atmospheres where they tend to become stiff. The use of fluorescent tubes overcomes some of these problems.

Table and standard lamps with upstanding bulbs also create problems with insects. Large numbers of these tiny creatures find their way in between the bayonet cap and socket of the lamp holder making it difficult to remove the bulb. Periodic removal and cleaning is desirable as this also enables the points and contacts to be maintained. Standard lamps should not be top-heavy since fairly strong winds can blow them over.

FLUORESCENT TUBES are now widely used in all types of building and their popularity is increasing. They consist of tubes of ionized gas through which an electrical discharge is passed. The presence of positive ions in a gas discharge reduces the voltage required to pass the current; thus fluorescent tubes, although more costly initially than incandescent lamps, consume much less electricity for the same wattage.

A typical mercury fluorescent lamp consists of a glass tube 40 mm in diameter and from 600 mm to 1500 mm long. It is usually filled with argon gas and contains a drop of mercury. The interior of the tube is coated with fluorescent powder, i.e. a phosphor. The main source of light is from fluorescence of the phosphor, hence its name. The pale blue light effect is caused by the mercury vapour discharge. Ambient temperature has an effect on the efficiency of the tube: the higher the temperature, the more efficient the light. It is thus suited to the tropics, but special arrangements must be made for cold stores.

The most popular size of tube is probably 1200 mm of 40 W. The power rating of tubes is normally about 10 W per 300 mm of tube, though not always: in the U.K. a 1500 mm tube of 80 W is often used. Fluorescent tubes are best suited to a.c. supplies but can be adapted to d.c. if desired.

Colouring. Fluorescent tubes can normally be obtained in five colours. These are Daylight, White, Warm white, Northlight, and Natural. Installations can also combine fluorescent with incandescent lamps. Tubing may also be coated with phosphor to give a variety of colours for sign display, etc. Groups of coloured tubes can also be arranged to produce decorative effects.

Starting control, noise and radio suppression. The most common tube is a hot cathode type requiring a higher voltage for ignition than the normal main supplies. There are several varieties of ignition starter most of which are heat operated. The starter is automatic once the current has been switched on. There are variations in starters, including instant starter circuits which eliminate the normal flickering prior to warm-up. Starting and radio suppression gear is normally housed in the tray above the tube. To reduce the humming noice from the fittings in libraries or quiet rooms, it is advisable to mount them on rubber buffers.

MERCURY VAPOUR AND SODIUM LAMPS. These are often used for outdoor lighting. The mercury arc lamp has been almost superseded by sodium, though both types are still in use. The normal mercury vapour lamp consists of two glass tubes the inner one, or arc tube, is made of hard glass and contains argon with a drop of mercury added; the outer tube may be left open. There are a number of kinds of mercury tube available Quartz arc tubes are widely used. These are enclosed in an outer tube of hard glass coated inside with a fluorescent powder which gives a blue-green colour. Mercury lamps are usually made in sizes from 50 to 100 W.

Sodium vapour is now used almost exclusively for main-road lighting. It is more efficient than mercury. Sodium has a low vapour pressure even at the high temperatures necessary to produce light. This temperature is achieved and maintained by placing the inner tube, usually U-shaped, in an outer jacket of high vacuum. The red neon glow sometimes seen in sodium street lamps is usually due to a failure of the outer vacuum jacket.

Sodium luminaires are available from 45 to 140 W, but a 280 W unit is also supplied which is really two lamps in one. They are usually fixed in a near-horizontal position to prevent liquid sodium from migrating towards the cathode where it could cause damage. One advantage of sodium is that it will restart immediately after a temporary power failure, unlike mercury which has to cool down before it can operate again.

ELECTRICITY

3.6 Introduction

The use of electricity is now so common that the reader needs to have at least an elementary knowledge of the subject. The field is wide, and it is not intended here to do more than introduce the common aspects which apply to building. Perhaps the best way of doing this is to use a straightforward example of a small tropical bungalow, giving details of circuit layout (Figs. 3.23, 3.24, and Frontispiece).

ELECTRICAL TERMS. Before progressing very far the reader will find it necessary to have some understanding of the more common terms used in electricity. The four main expressions are:

Volt, V	Unit of electrical potential (pressure)
Ampere (or amp.), A	Unit of electrical current
Ohm, Ω	Unit of electrical resistance
Watt, W	Unit of electrical power

A well-known method of describing voltage is to make an analogy with water pressure. The greater the head of water, the greater the pressure at the point of discharge; also the larger the supply pipe in section, the greater the flow.

Thus power (W) = pressure (V) × flow (A)

The smaller the supply pipe (or cable in this case) the greater the frictional resistance. This is important in electricity as the resistance affects the size of the cables that may be used.

$$\text{Thus resistance } \Omega = \frac{V}{A}$$

Older installations in some districts are still supplied with direct current (d.c.), as distinct from alternating current (a.c.) which is now used almost exclusively and which can be produced more cheaply and at higher voltages. The type of current and the voltage must be checked before installations are planned.

For domestic installations single-phase current is normally used, and for industrial purposes three-phase current is used. The Electricity Authority's cable is normally three-phase at 440 V (a.c.) supplied to the point of entry. This is supplied as 'four-wire' which consists of three supply wires and a neutral. The voltage between any pair of supply wires would be 440 V, but a supply wire and a neutral would give a voltage of 250 V single-phase. This is normal for domestic work, though it varies with different countries.

EARTHING. Should the live wire (or *line* as it is usually called) touch the metal framework of a domestic appliance, it would give the user an electric shock. To prevent this, non-permanent appliances are normally earthed. This consists of connecting the earth wire to the metalwork of the appliance and leading it, via a third wire in the outlet socket, to the ground. If water companies permit, the earth wire in a domestic installation may be secured to the supply side of the main water cock. Where no main exists, the electricity company will supply an earth.

Most modern appliances now have a square three-pin plug. The largest pin is normally the earth. Care must be taken to wire the earth to the correct pin. Despite attempts at standardization, the colour of the earth wire still varies from one country to another, so imported appliances have to be checked to ensure correct wiring.

CABLES. The two sizes of cable in popular use for domestic work are $1{\cdot}0\ \text{mm}^2$ cross-sectional area (i.e. 1/1·13 mm diameter) for lighting, and $2{\cdot}5\ \text{mm}^2$ cross-sectional area (i.e. 1/1·78 mm diameter) for ring mains. Above this size cables are usually manufactured in strands to make them flexible. The cables are normally sheathed or insulated with plastic. They may be obtained singly or as twin cables, or as twin cables with an earth for socket outlets.

Where cables are buried in concrete or plaster rendering, they are enclosed in either a P.V.C. or a metal conduit. When laid above the ceiling, as in the example given here, they may be clipped to the ceiling joists. For high-class work, mineral-insulated copper-covered cables (M.I.C.C.) are used. These need no conduit and can be buried, or used as surface wiring, as required. They are very durable, and provided they are properly installed and the insulation is not fractured when laying, they should last the lifetime of the building. They are expensive however.

3.7 Electrical installation in a bungalow

Figures 3.23 and 3.24 show the plan of a bungalow, designed for use in West Africa, which will be used as an example for suitable electrical installation. Generally, the rooms are larger than in Europe, and a wider spread of lighting is necessary, together with a greater number of socket outlets. Owing to the present preference for spot rather than overall lighting, coupled with the tendency for the ceiling fan to occupy a central position, the trend is to increase the number of wall outlets and to use socket outlets for standard spot lights where necessary.

Two diagrams have been given, Fig. 3.23 showing the lighting arrangement and Fig. 3.24 the socket outlets and fans. Telephone points have also been inserted, although these are quite separate from lighting circuits.

The Electricity Authority is usually responsible for bringing the cable to the house switchboard, although this needs to be checked with the authorities concerned. The normal procedure is to install a Consumer's Supply Control Unit (C.S.U.) in a convenient place in this case the garage, though the front porch position might have shortened the cable run and enabled the meter to be read at all times. The cable should be brought in from underground through drain pipes using easy bends; sharp corners are to be avoided.

Fuseways. In domestic work the C.S.U. normally consists of a small metal cupboard containing the meter, mains switch, and up to eight fuses each of which provides for a separate circuit. In the present example the circuits have been arranged as follows:

No. 4 5A lighting circuits, namely:

1. Living room, porch, bedroom 1. (10 points);
2. Living room ceiling light, dining recess, passage,

w.c., bath. (6 points);
3. Kitchen, larder, bedroom 2 and bedroom 3 (10 points);
4. Garage, utility room, steward's quarters, and yard. (8 points).

No. 2 Socket outlet circuits (30 A):
1. Living room, bedroom 1 only;
2. Garage, utility room, kitchen, bedrooms 1 and 2;

No. 1 circuit direct to immersion heater (15 A);
No. 1 circuit spare or for electric cooker, if needed.

Lighting circuits. A diagram of circuit No. 1 is shown. The main cable (line and neutral) has been drawn in, showing the main route with branches to the bedroom wall lights. The branch to the second wall light in the living room is simply an extension operated by the one switch.

Exercise 3.2. Draw in the route for lighting circuit No. 2 showing main line and branches.

It is unwise to exceed ten points in a circuit because of the danger of overloading. A 100 W lamp at each of the above points will theoretically produce 1000 W if all were on together. To produce 5 A current the ten points could each burn a 120 W lamp at 240 V.

A diagram of the lighting circuit is shown in Fig. 3.25. This shows clearly how the circuit is made when the switch is on. The switch is down for 'on' except when two-way switches are used. These operate very simply as can be seen from Fig. 3.26 which shows an 'on' position. Release of either switch would break the circuit.

Socket outlets. These are usually taken direct off the ring main, i.e. a complete circuit contained in a 30 A fuse at its ends. It can thus supply current at both ends, unlike the lighting circuits.

The normal regulation governing socket outlets in domestic installations is that one circuit can carry as many outlets as necessary, provided that it does not supply an area greater than 100 m^2. As each appliance has its own fused plug there is little danger in this arrangement. It is inadvisable to cut down on the number of socket outlets, as the tendency is for an ever increasing number of appliances to be put on the market, such as radio and television receivers, food mixers, vacuum cleaners, table fans, fume extractors, humidifiers, air conditioners, tape recorders and cassettes, record players, spot lights, etc. Outlet points are always in demand.

The bungalow shown has an area of 107 m^2, so two circuits are necessary. These could be divided conveniently into kitchen, bedrooms

2 and 3, and utility room on one circuit, and living room, bedroom 1, and garage on the other. Where spurs or branches are taken off the ring main, they should not exceed two in number on any one spur. Not more than half the sockets on the ring should be connected as spurs. Twin with earth 2·5 mm^2 cable is normally taken from a 30 A fuseway with 13 A socket outlets. A 30 A fuse or miniature contact breaker (m.c.b.) protects the ring main itself with a cartridge fuse inserted at each plug. These are available in ratings of 3 to 13 amps, but as plugs are usually sold with only 13 A fuses fitted most appliances are over-fused. Inadequate supplies of fuses, especially in isolated areas, also lead to fuse cartridges being repaired with any wire available. But cartridge fuses and m.c.b.s are generally much more satisfactory than the old rewireable fuse, and less trouble to reset.

Fixed appliances, such as air conditioners, normally have *fused spur boxes* which are attached to the ring main in the normal way. Ceiling fans usually have a fixed starter box. A large appliance, such as an immersion heater, would probably need a separate circuit to itself and this has been allowed for. The switch shown outside the bathroom is of the *double pole* type with a neon warning light to show when the water heater is on. The heater is also fitted with a thermostat which can be adjusted to any required temperature.

It is advisable to keep one circuit spare to allow for extension or improvement. The spare point here, for example, could be used for an electric cooker. A 30 A fuse would then be needed on the fuseway and heavy wiring would be necessary. For a small domestic cooker, a control unit is fitted on the wall about 1·5 m high and a little to the side of the cooker position. This usually has an extra 13 A socket fitted as an outlet. From the unit a length of 6 mm^2 tough rubber- (or plastic-) sheathed cable is run through a conduit to a cable outlet to which the cooker is connected.

Separate circuits. Where a single circuit is not overloaded, an extra circuit may be wired into the fuseway by means of a *splitter fuse.*

Electrical installation

Fig. 3.23 Electrical lighting installation to bungalow

Fig. 3.24 Socket outlets and fans

Fig. 3.25 Diagram of lighting wiring

Fig. 3.26 Two-way switch arrangement

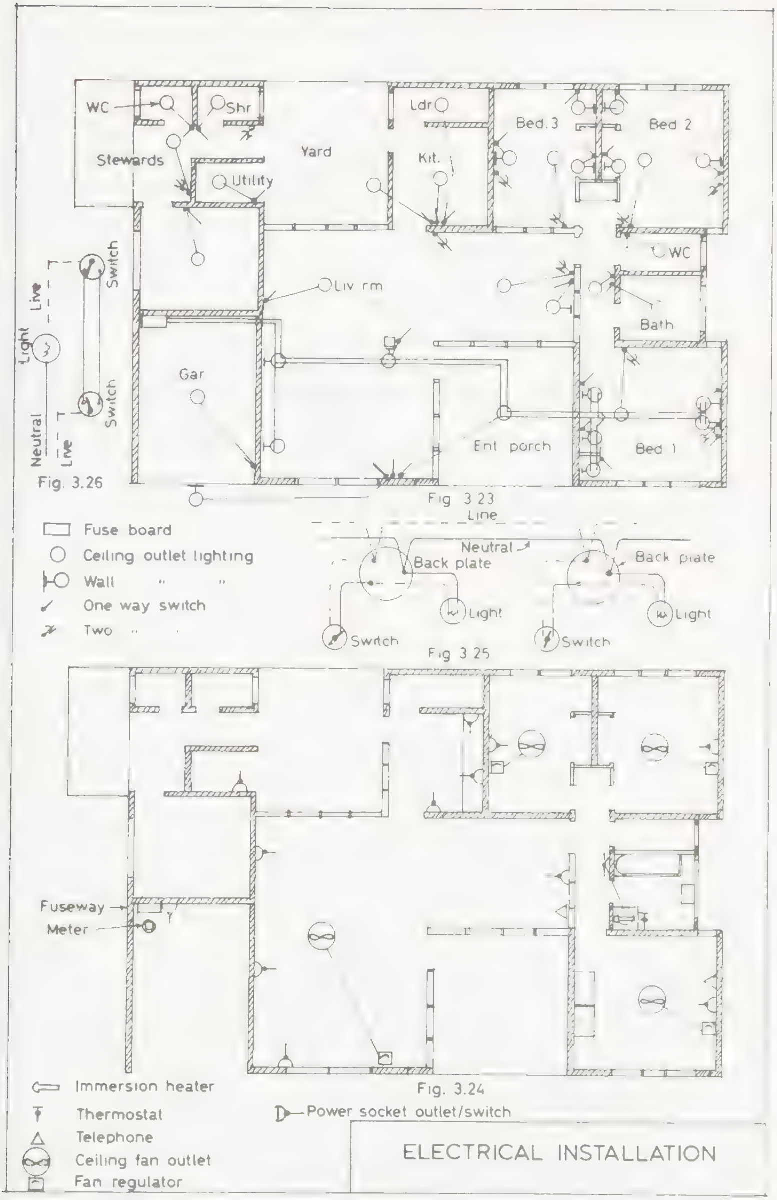


Fig. 3.26

Fig 3.23

Fig 3.25

Fig. 3.24

ELECTRICAL INSTALLATION

The arrangement permits, say, a 30 A supply to be divided between two 15 A fuses, each providing a separate circuit. Such splitter fuses are often used in electrical circuits.

3.8 Safety precautions

There are a number of safety precautions which must be observed and which most Electricity Authorities insist upon. Bathroom switches, for instance, must be at ceiling level and operated by a pull-cord. Alternatively, they may be fixed outside the bathroom. Ceiling fittings should be of the skirted type with an enclosed bulb. Where metal fittings are used they should be earthed for safety, although this is not always done.

Where cables pass through sheet metal care should always be taken to avoid fraying the cable insulation. Special bonding nipples are obtainable for this purpose. Further information on testing of circuits is given in Volume 3.

The above must be taken only as an introduction to the subject. The reader is advised, despite possible shortage of skilled electrical personnel, not to attempt practical undertaking of an installation without further guidance and instruction.

AIR-CONDITIONING

3.9 Introduction

While mechanical ventilation can do much to improve comfort, particularly in the temperate/tropical zones, areas of high humidity or torrid zones need some modification of the environment. The answer frequently lies in air-conditioning.

Air-conditioning provides for the control of temperature, humidity, purity of air and flow within an enclosed space. Cool air blown into a room by a fan is not strictly air-conditioning, although it is often referred to as such.

In tropical countries air-conditioning consists mainly of the provision of clean air at regulated temperatures and at a velocity sufficient to maintain comfort. In temperate climates heating coils are usually inserted into the circuit for winter use. This provision is also made in countries where climatic conditions vary from tropical in summer to freezing in winter, e.g. the Far East. This chapter, however, will be confined to tropical conditions only.

3.10 Principles of air-conditioning

Certain gases are termed 'refrigerants' and are also known as 'liquifiable vapours'. These vapours or gases become hot on being compressed. Hot gas is then passed through a condenser a cooling device which causes the gas to be reduced to a liquid. This liquid, still under pressure, is forced through an expansion valve a narrow orifice into an evaporator Having been released from pressure, the liquid expands into a gas, absorbing heat from the evaporator in order to do so. The evaporator may be in an *air intake chamber* (*D*, Fig. 3.14), it could be situated inside a refrigerator or cold store, or it could also be a chamber containing water tubes which thus become chilled (*D*, Fig. 3.20). The gas is, of course, sealed in a closed circuit. It is then returned to the compressor when the cycle is repeated. The operation can be followed from studying Figs. 3.14, 3.16 or 3.20. The most widely used gas for refrigeration or air conditioning is Freon-12, although others, e.g. Arcton, methyl chloride, and ammonia, are used for different purposes.

The schematic diagram in Fig. 3.14 shows the principles of air-conditioning. Outside air is drawn in at *A* through ducts. It then passes through filter *B*, or water spray *B*1, or both, to reach the cooling coil *D*. This water is cooled by the action of the compressor and condenser *C* which circulates refrigerant in a closed circuit. The cool clean air is now forced through ducts *H* by means of a fan and motor *E* and *G* It is then discharged where required by means of open grilles.

DISTRIBUTION OF AIR Because of the tendency for cool air to drop the ducts and grilles are usually placed at ceiling level. The air may then be extracted at floor level by ducts and returned through *J* for recirculation. In smaller installations the air from duct *H* may be ejected directly into the area through a grille, thus cooling it by direct expansion. In this case a fan would be placed at *K* to assist circulation. Four way louvres are usually in grilles in order to spread the air stream and reduce draught.

In large installations the unit must be carefully designed since ducting can sometimes create problems. It is usually rectangular in shape for the sake of appearance. The provision of insulation to reduce fan and compressor noise and the loss of cold air must be considered. For this reason ducts are heavily wrapped, normally in foam plastic or other lightweight insulation. Air intake is usually at roof level where the water spray and fan are installed, although this is not always the case. Roof-top installation has the advantage of saving space in the building; since the equipment, though light in weight, is very bulky. The heavy compressor is then placed in the basement or at ground level and screened against noise. It may be placed outside the building if preferred, Fig. 3.15.

CHILLED WATER SYSTEM. Figure 3.15 shows a diagram of a system using chilled water as the cooling medium. The compressors *B* with either water-cooled or evaporative condensers *A* are used to chill water in a closed circuit by passing refrigerant through the evaporator or water chiller *C*, as explained earlier. The chilled water in the pipeline *E*, is then used as required. Separate air handling units may be necessary with this system. These may take several forms, the most usual being the type designed to go under a window containing fans and a chilled water coil, Fig. 3.22a.

Water-cooled or evaporative condensers may be used with either town water or water circulated through a cooling tower system.

3.11 Packaged air-conditioning

These air-conditioning units are self-contained and complete with cooler, filters, dehumidifiers, and ventilators. They can also be supplied with heating coils if required. Figure 3.16 shows a typical cabinet with the front removed. These are supplied in various sizes and the cabinet shown might well be about 2 m high depending on its capacity.

The vertical condenser *N* is water-cooled in this case. Thermostatic control regulates the air temperature. These thermostats are not supplied with the larger models, or where remote-control thermostats are required. The cooling coils *F* are usually copper, with aluminium fins to provide for maximum heat transfer.

The capacity of the air, and leaving-air conditions of different models can be determined by means of charts provided by the makers. With their aid it is fairly simple to arrive at the size of unit required. On larger models the grille *A* can be replaced by a duct if required.

Unit air conditioners for single rooms are now very popular in the tropics. These cabinets are approximately 600 × 750 × 460 mm and will serve a room up to 34 m^3. The unit is fixed to an outside wall to give a fresh air intake of 5 m^3 per minute. It can be run off a standard 13 A socket outlet.

A large packaged liquid chiller in simplified form is shown in Figs. 3.20 and 3.21. It works on the principle of *centrifugal compression*. The water to be chilled flows through tubes *D* and gives up its heat to the surrounding refrigerant, which then boils and vaporizes. The eliminators *B* act as filters which prevent liquid carry-over to the compressor. The compressor *A* raises the pressure of refrigerant to condensing level. It then passes through the condenser *E* and gives up its heat, thus becoming a liquid. The higher pressure in the condensing chamber forces the liquid through the float valve *G* into the distributor *C* where it vaporizes once more.

Full instructions on installation and the procedure for selection of models are given in suppliers' handbooks. The unit is small enough to pass through an opening 1 m wide and can be installed in existing buildings.

3.12 Distribution of chilled water

Water, having been chilled by evaporators, may be used in many ways. For example well-lagged pipelines can be taken to chambers needing background cooling, or to semi-cold stores for controlling humidity and keeping materials at an even temperature. The most general use of water in air-conditioning, however, is in under-window units, Fig. 3.22a. Chilled water passes through the cooler *A* and automatically-controlled air enters from outside grilles *G*.

The operation is as follows:

Figure 3.22b shows the damper position for early morning when the outside damper is closed. The room temperature is above thermostat setting. In this case all room air enters through the open damper *K* and passes through the cooler, being drawn in by the fan. The face damper *B* is closed.

Figure 3.22a itself shows the damper position when the temperature approaches thermostat setting. Damper *J* opens slightly and the face damper begins to modulate. Figure 3.22c shows a normal position. The required temperature is kept by a combination of outside air and face damper which modulates to provide temperature control.

Figure 3.22d shows the position for night purging if the air is cool. All outside air is used for maximum ventilation and cooling to reduce the load on the mechanical refrigerator. All the above operations are entirely automatic once the thermostat is set.

Chilled water units have the advantage of automatically controlling humidity. All air passing through the coil is dehumidified, the condensate water being collected in tray *E* and led to waste.

3.13 Air cleaners

The normal method of cleaning air prior to circulation is by filter *B*, Fig. 3.14. Filters normally consist of three types, disposable, renewable, and washable. Renewable type filters consist of a permanent frame filled with disposable filter media. Cartons of media are supplied by the manufacturer on request. The frames are easily removed and refilled. Filters can also be of the replaceable type, the whole filter being discarded when maximum dirt accumulation is reached. They can also be of polyurethane foam type for repeated re-use after being washed in soapy water.

Filters can also be of the permanent type. One popular make consists of fine-mesh galvanized steel filters built up in alternate layers of flat and herringbone crimped sheets fitted into holding frames. These may be repeatedly re-used when cleaned and sprayed with oil adhesive. Any of these types may be fitted as shown in Fig. 3.16, *G* or *F*, Fig. 3.22a. Replacement of screens is a simple task. A further development of this method is the use of the roll type filter which uses glass fibre material. The filter automatically rolls itself off one spool on to another, lighting a warning lamp when the spool is finished.

Electronic air-cleaners are also widely used. The principle of operation need not concern us here. Suffice it to say that dust particles in the air are passed through an *ionizer*, Fig. 3.18. A fine ionizing wire *A*, maintained at 12 000 V, produces an intense electrical field between two earthed plates *C*. Ions are attracted to the plates, and charged dust and smoke particles adhere to them. The accumulation of dust on the plates is then dislodged either by washing or being carried by the air stream into filter bags behind the Precipitron. Figure 3.18 illustrates the principle diagrammatically. Figure 3.17 shows a cabinet Precipitron with collector cell *C* in position.

3.14 Humidifying

In some tropical countries air humidity needs to be controlled for the sake of comfort. In warm wet regions the humidity may be excessive, while in hot dry areas sometimes subject to temperature drop it may be necessary to add moisture to the atmosphere. The normal system for controlling humidity is by moisture adjustment. The addition of moisture may be done during the process of air washing after the incoming air has been passed through the filter, Fig. 3.14. Dry air will absorb moisture during the spraying process and, on cooling, by evaporation.

Pre-heating of the air entering the spray channels will tend to increase humidity. Also, if the spray water is heated, humidity will tend to increase. One method of dehumidifying air is to cool it below its dew point, thus releasing moisture; another way is to pass the air through condensers in which chilled water is being circulated.

A common type of small dehumidifier is shown in Fig. 3.19. The humid air passes through a coil cooled by a fan and the condensate is collected and drained away. The air then passes through a condenser cooled by a refrigerant. The model shown (without its cabinet) is portable and will dry enclosed air up to a volume of 280 m^3 capacity. The complete unit is, of course, contained within the room.

REFRIGERATION

3.15 Principles

Refrigeration, which has been discussed under air-conditioning, may also be applied to refrigerators and cold stores.

In domestic models the compressor is usually maintained on springs or rubber blocks to reduce noise and vibration.

The condensers are normally air-cooled coils as shown in *C*, Fig. 3.19, and the liquid refrigerant is taken by small-bore tube to the freezing compartment of the cold cupboard, which acts as an evaporator. Since the evaporator acts also as a dehumidifier, moist foodstuffs need to be covered. The back of a refrigerator with an air-cooled coil should never be enclosed.

Some refrigerators are run off bottled gas or kerosene, while others can be operated both by electricity and kerosene depending on supplies. These are popular in outlying districts where electricity supplies are unreliable or intermittent.

The normal refrigerant is Freon 12 or sulphur dioxide, but ammonia is still used for large units in cold stores, Fig. 2.64.

SPECIALIST SERVICES

3.16 Types of services

These cover a wide range in modern building construction and are extending continually to keep abreast of developments. Services in modern complexes deal largely with communications, the main items being:

Telephones: external telephones and internal intercoms.
Bells; staff location and alarm signals
Electric clocks and time recorders
Radio and television relay equipment
Public address systems

Builders' work in connection with the above can be complex and needs to be planned at the carcass stage if much cutting and making good is to be avoided. There have been cases, in research laboratories and industrial complexes, where because of their complexity, conduits, water, gas piping, and service and supply lines including cables have been installed before the building commenced and extended as the work proceeded. This is often done with prefabricated work.

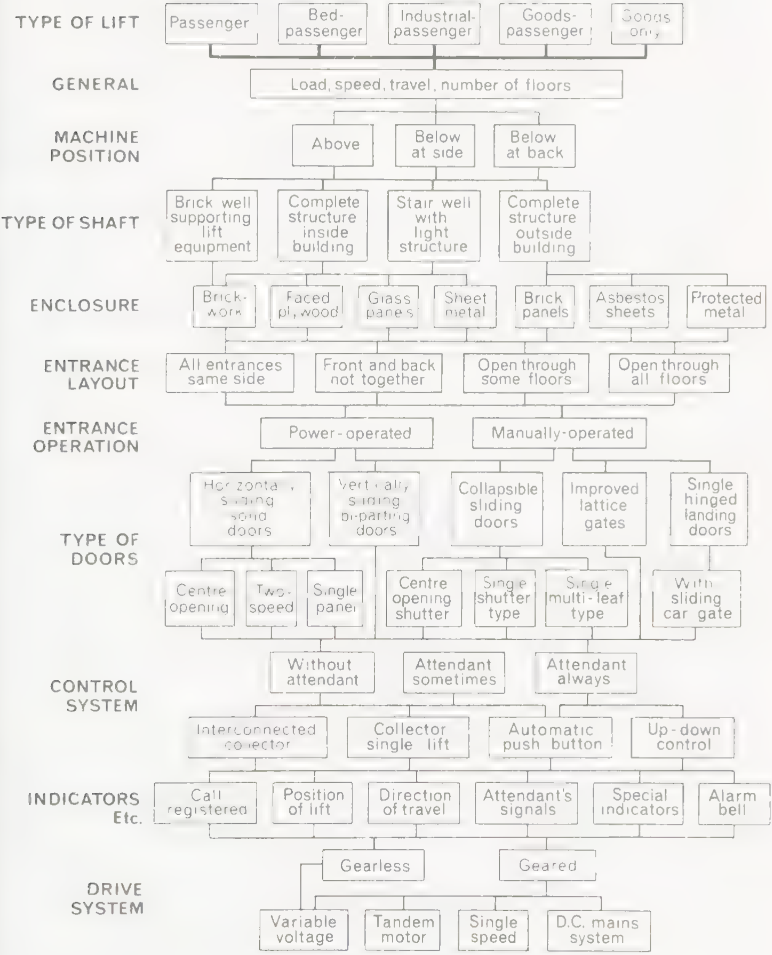
DUCTING. In important work, service ducts such as crawlways, trenches, and casings of metal or masonry, both horizontal and vertical, are planned on the drawing-board. Local Authorities' regulations regarding separation of service ducts for different purposes may have to be observed. Plumbing and sanitary ducts, for instance, may not be used for some electrical services, also telephone cables may not be laid alongside electric cables as they are of much lower voltage. Access panels to ducts must also be considered. The possible use of ventilation shafts, where permitted, or lift walls may also be considered.

CONDUITS AND TRENCHING. Arrangements for such tubes or trunking as may be necessary need to be made at the design stage. The size and type of such communications, the material, the location of junction boxes, the provision for easy sweeps, and the suitability of cables all need careful thought. Consideration may have to be given to the use of hollow floors, false roofs, ceilings, and steel decking through which wiring or cable will pass. Servicing problems are frequently encountered where the design calls for the use of hollow internal partitions which may be taken down or re-erected as the needs of the occupants change. In such cases tapping off from main lines at convenient locations must be provided for. As already stated, movable hollow partitions frequently have provision made for housing of wiring. It is, of course, also necessary that adequate provision be made for re-routing or disconnection of services on removal of the dividing wall.

A point frequently overlooked is the provision of lighting flex, telephone leads, etc., from wall to office desks. At one time flooring boards could be lifted to accommodate them, but, with the widespread use of polythene flooring and fitted carpets, wiring often has to be stapled to the floor, usually without even a cover strip. In many cases this could have been avoided with simple pre-planning.

LOCATION OF EQUIPMENT. The position of electronic, telephone, radio and electrical apparatus, meter switchboards and the like must be decided at an early stage of planning. Air-conditioning and dehumidification may have to be provided for, in which case it may be desirable to have such equipment grouped together if possible. It may also need to be reasonably near to the inlet cable or main supply. The use of tropicalized gear may also offer an alternative to dehumidification. Delicate electronic gear, including sensitized apparatus, does not stand up well to warm humid conditions and special attention must be paid to its location. The main thing is to be aware of the problems involved and to plan to meet them as far as possible.

TABLE 2
LIFTS – QUICK REFERENCE DATA



3.17 Lifts

As development proceeds in tropical countries lifts are being more widely used. The chart (Table 2) shows the range of electric types available, which are dealt with here. Kitchen, hand-operated, and 'oildraulic' lifts have been excluded because of lack of space.

TYPES OF LIFT. There are, by and large, two types: goods and passenger, and the range of each is wide. A normal passenger lift is from 2 m to 3 m square. An average goods lift will take a hospital bed or a motor-car.

Load. An average passenger lift will carry from, say, six to twelve people; a goods lift, say, 0·5 tonne to 3 tonnes.

Speed. The average speed of passenger lifts ranges from 30 m/min. to 90 m min. Express lifts go faster. A goods lift travels about 10 m/min.

Travel. This distance refers to the number of floors served, plus the lift pit and overhead height.

Machine position. This is best placed above the lift if possible. It should be mounted on a 76 mm insulation of cork to reduce noise. The machine room should be well ventilated and should be fitted with a steel joist over the machine for lifting purposes. A socket outlet should be provided with a wandering lead to assist maintenance

Type of shaft. Brick or concrete loadbearing shafts are popular, although steel shafts are also used. The structure is provided by the lift maker and installed by him, but the preparatory work to entrance and supports is normally done by the builder.

Enclosure. The shaft structure may be enclosed by any of the materials listed in Table 2.

Entrance layout. The position of entrances needs to be specified. With power-operated doors, front and back entrances normally operate together if on the same level. Builders' work to entrances, particularly the floor trim, needs to be accurate and the floor made dead level.

Entrance operation. Both power- and manually-operated doors are usual. In countries where lifts are not widely used and reliable servicing not to be counted upon, the simplest and the sturdiest are usually the best. Hand-operated lattice gates are best in such circumstances. They are reasonably trouble-free and also permit good air circulation.

Control systems. These can be most complex where large numbers of people need to be moved quickly. Several lifts, for instance, may be interconnected thus enabling the operator to deal with all calls in sequence. The commonest, however, is the simple push-button, attendant operated lift, particularly where labour is plentiful and passengers comparatively few.

Indicators. Generally some form of call-registered indicator is placed on the landings of tall buildings and a position indicator usually placed above the lift entrance. It may be placed in the car itself. Alarm systems are installed in most passenger lifts. These should be battery as well as mains operated as a safeguard against power failure.

Drive system. The normal drive system operates through worm reduction gears which operate *geared lifts*. For high-speed lifts, however, a large low-speed motor is installed, which eliminates gears. These motors are *variable-voltage* controlled, making it possible to stop accurately at floor levels from high speeds. Geared machines, however, are cheaper. Frequently these have two-speed or tandem motors in order to achieve a low decking speed before stopping. These can be used for speeds up to, say, 60 m/min.

ESCALATORS. Moving staircases are in wide use in Europe and are very effective for moving large numbers of people quickly. They are very popular in busy department stores, airports, and prestige buildings. As yet they are not in widespread use in the tropics. The principle of operation is quite simple. A horizontal four-wheeled platform or step is mounted on four rails; the front (riser) supports are higher than those behind in order to keep the platform level. At landing level the front-wheel rails are positioned lower than the back, thus bringing all platforms into line. The steps have flexible risers, and the whole constitutes an endless belt. Direction and speed are variable. Escalator capacity and the builder's work involved are discussed briefly in Volume 3.

3.18 Food services

Small establishments catering for up to fifty people may manage with locally-made ovens and ranges, if better equipment cannot be afforded. Those in better financial circumstances may use modern kitchen ranges, of which there are many types. The ranges can be fired by gas, coal, electricity, or wood and can supply hot water if desired.

Large organizations such as hospitals, colleges, offices, and factories now install efficient catering equipment capable of dealing with large numbers of diners in a short space of time.

TYPE OF EQUIPMENT. The essential basic equipment required for a kitchen is not affected by the greater consumption of different foods in different localities e.g. yams in one area and chips in another; but the quantities of the various equipment required may tend to vary with local needs. Basic kitchen equipment can consist of some or all of the following:

> Boiling pans and tables; water boilers; hotplates; stockpot stands, steaming, baking, roasting and pastry ovens; fryers; grills, toasters, milk urns; hot cupboards; bakeries, bains-marie.

They are usually fuelled by gas or electricity. A boiling table is generally the working top of a range but it may be separate on its own stand. A stockpot stand is normally a single-burner boiling table. A griller is used for toasting or for grilling meat, etc. Hot closets are warming ovens or hot cupboards. A bain marie is a shallow pan containing very hot water, foods such as sauces, soups, and custard are placed in containers which are then partly submerged to keep them hot.

Tropical kitchen layout

Fig. 3.27 Kitchen layout
A Lockers
B Urinal
C Wash-basins
D Shower
E W.C.s
F Refrigerators (one kerosene)
G Sink units
H Cooking ranges (electric and gas)
J Mincer
K Electric water heater over
L Fryer
M Gas cookers (alternative)
N Hot or cold drinks
O Boiling pans
P Hot closets
Q Collection trolleys
R Pot and pan racks
S Compressor
T Platform scales
U Mixer
V Steaming oven

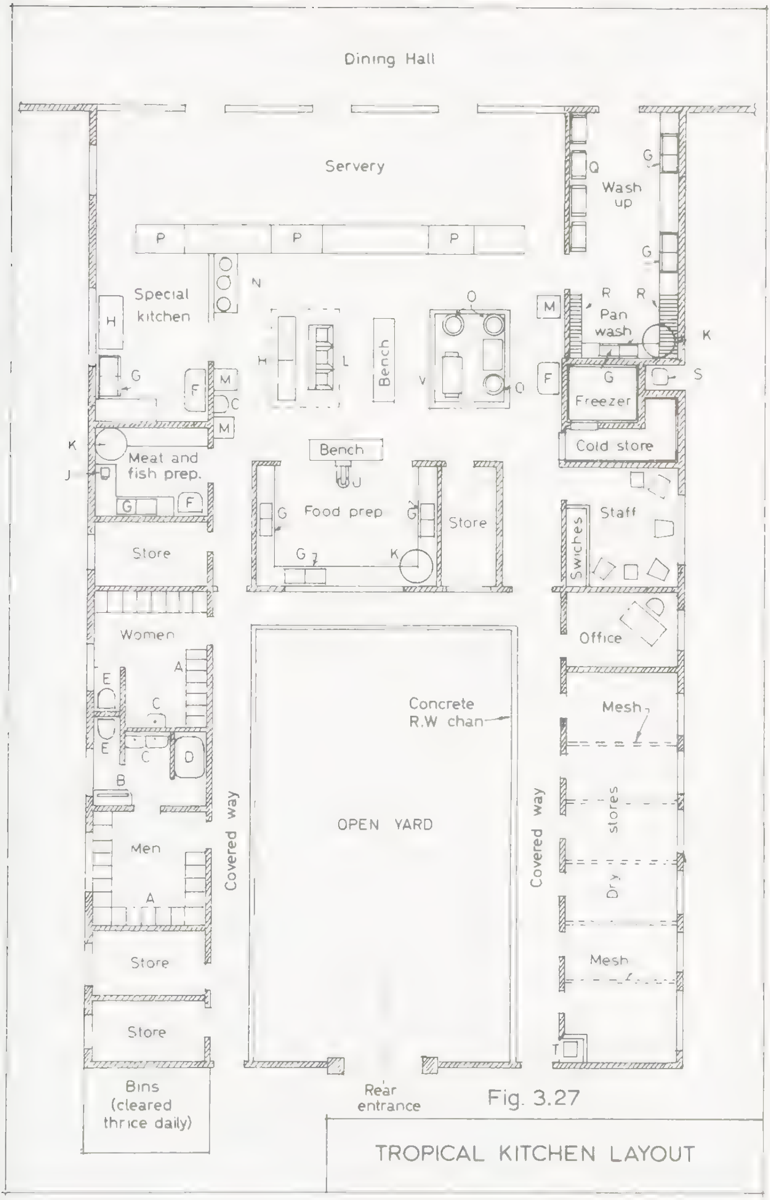


Fig. 3.27

TROPICAL KITCHEN LAYOUT

Steaming ovens are often used for the quick cooking of vegetables, fish, puddings, or meat. Sometimes chicken or meat is partly steamed and then finished off in the roasting oven. In addition to the above, large kitchens may also have dishwashers, food conveyors, soda fountains, refrigerated service counters, chilled water points, etc.

3.19 Kitchen planning

The success of a kitchen depends on a well-planned layout. A good plan should follow as closely as possible the order in which food is prepared, though this is not always possible.

Many catering equipment suppliers have standard plans drawn up to meet various needs, and these can be of great help to planners. Before a plan can be drawn up the supplier would need such information as:

Number and type of meals to be provided; if a canteen, the number of sittings.

Type of fuel available, whether gas, steam, electricity, or coal, with details of pressure, voltage, etc.; location of dining-room in relation to kitchen.

Type of service: self-service or steward.

Orientation: position of cold storage unit, etc.

Type of ventilation or air-conditioning.

Special installations: water coolers, refrigerators, waste-bin areas, supplementary cold stores, etc.

Type of finish to equipment and counters.

The type of equipment should be selected with a view to its efficiency and economy in operation, maintenance costs, capacity, working life, ease of cleaning, etc.

A typical kitchen layout in tropical conditions for, say, 350 people is shown in Fig. 3.27. This is designed for steward service but is capable of easy conversion to self-service should the need arise. It is fairly simple in plan with no steaming apparatus, pastry ovens, refrigerated counter, etc. Hot water is supplied by multi-point electric water heaters, as there is no boiler house. Both electricity and bottled gas are provided as a precaution against power failures.

CLEANLINESS. Kitchen cleanliness is all-important and must be considered at the planning stage.

All fittings should have metal tubular legs with ends sealed to prevent the ingress of insects; wooden legs are liable to attack by wet rot where floors are frequently sluiced.

Wall shelves must be kept clear of the floor, preferably supported by wall brackets. The back should be a few centimetres clear of the wall to facilitate cleaning.

Enclosed cupboards are not desirable. Mesh should be used where security or fly-screening is necessary. Walls should be tiled, ceramics being preferable to plastic. All angles, both internal and external, should be rounded.

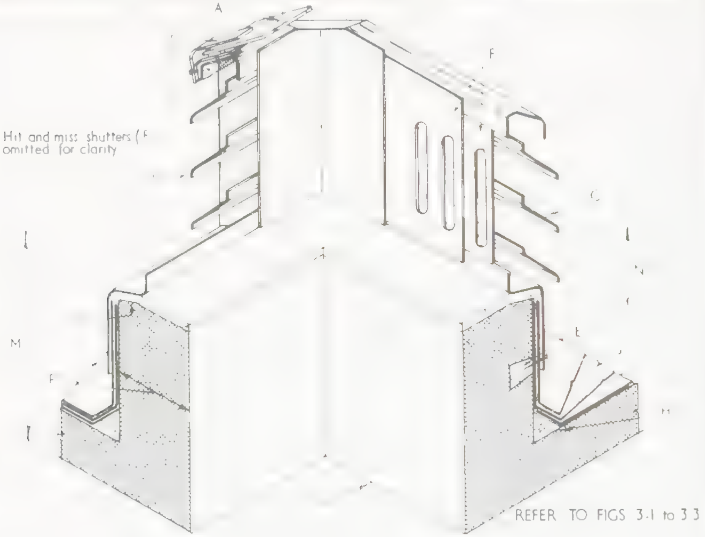
Quarry tiles are most suitable for the floor. Service pipes should preferably be laid before the wall or floor finish is applied, with outlets placed near the machine or equipment requiring them. Service pipes should not run along walls, especially in a horizontal position. Channels with removable gratings should be provided around the boiling table area.

Insects must be guarded against by periodic spraying with non-toxic insecticide. Ant runs should be constantly watched for and enclosed light shades emptied of dead insects and washed out.

VENTILATION. This is an important aspect of planning, particularly in areas of high humidity where corrosion must be guarded against. It must provide comfortable working conditions, prevent condensation, and contain cooking smells.

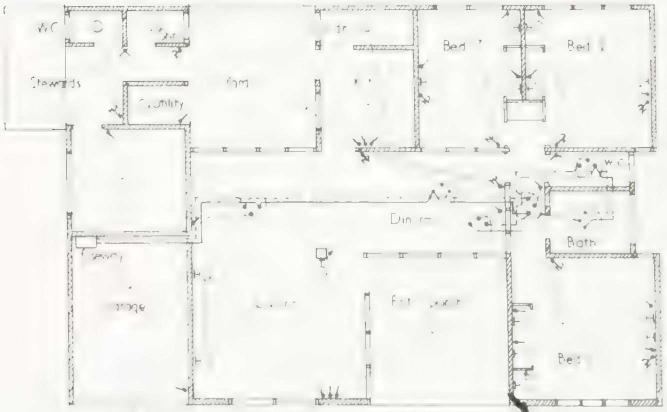
Mechanical ventilation is usually based on a combination of ducting and fans. Canopies over cooking areas may be constructed of anodized aluminium, Georgian wired glass, or plastic which is now very popular. Extractor fans, ducts, and lighting may be built into canopies. If required, removable grease filters can also be fitted, though these do not preclude the necessity for periodic cleaning and renewal.

Air changes in kitchens are usually based on the equipment used, spacing and the amount of use it receives. Such calculations are normally the work of the ventilation engineer. As a rough guide, however, between 25 and 40 changes per hour are usually recommended.



REFER TO FIGS 3.1 to 3.3

ANSWER TO EXERCISE 3.1. LOUVRE VENTILATOR



REFER TO FIGS 3.23 & 3.25

ANSWER TO EXERCISE 3.2 LIGHTING CIRCUIT

4 | Plumbing and Sanitation

4.1 Introduction

As with many trades in the tropics, particularly in the underdeveloped countries, non-traditional skills such as plumbing and water engineering are not as highly evolved as the old-established crafts.

It is particularly fortunate, then, that in recent years plumbing and sanitation systems have become much simplified. This is largely due to the introduction of new materials and the comparatively easy techniques needed to manipulate them. The use of plastics is an outstanding example of this and will be dealt with here, together with other materials used in tropical plumbing.

4.2 Drainage

This is the art of drawing off rain, waste water, and sewage. In the case of sewage, all drainage must be done by pipes, but in the case of water, either pipes or open channels may be used.

A good drainage installation should be capable of functioning effectively with the minimum of attention. It should be able to collect foul water for discharge to a sewer, septic tank, or other means of disposal, without nuisance or danger to health. Unfortunately, good drainage practice can sometimes prove costly and is often reserved only for good-quality building where private sewage-disposal plants can be installed.

Before deciding on a drainage plan it is advisable first to study the local building regulations to ensure that the plan is, in fact, capable of being carried out. Where towns have an efficient sewerage system the task is simplified, but otherwise it will be necessary to construct a separate means of disposal.

Frequently drainage systems in old-established towns are out-dated, particularly in areas like suburbs where there is rapid growth. This is a problem of sewerage and will not be dealt with here. Bad drainage, however, can also be due to laxity on the part of the Local Authority, poor design of public latrines, lack of suitable materials, equipment, and labour and too-long-established local custom.

OPEN CULVERTS. This method of drawing off excess rain-water has

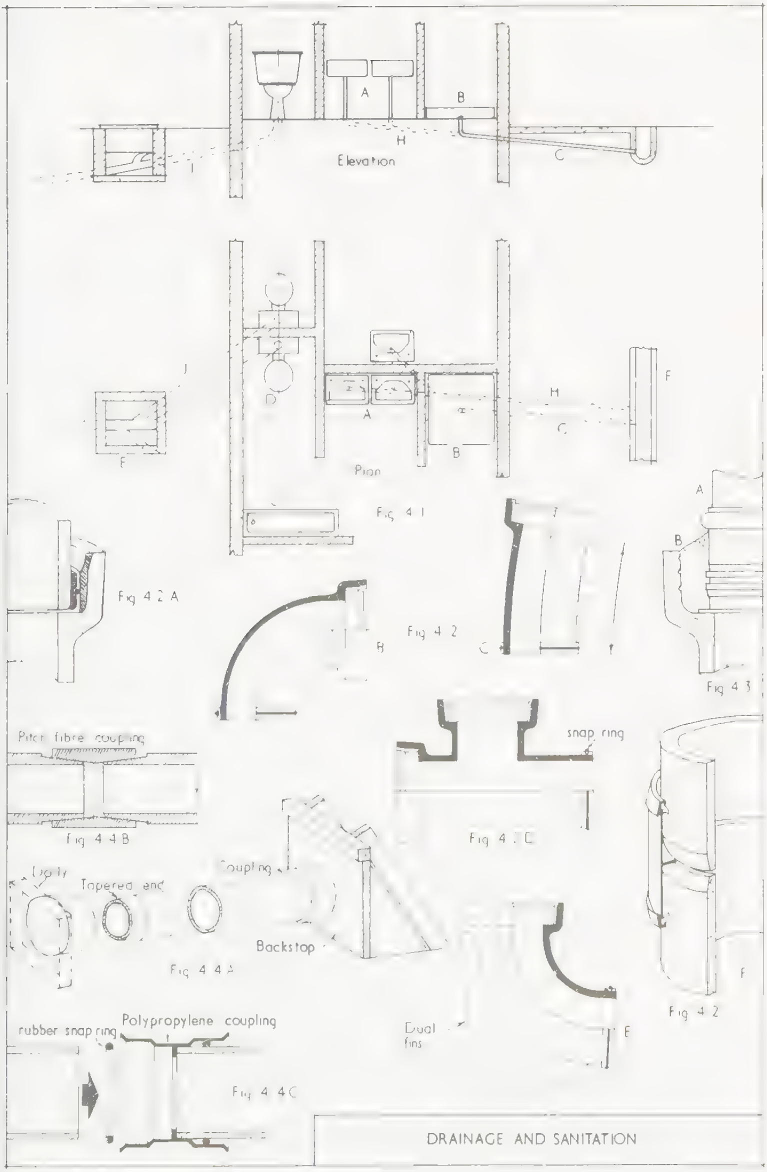
Drainage and sanitation

Fig. 4.1 Drainage and sanitation
- *A* 560 mm × 460 mm × 220 mm vitreous china wash-basins 790 mm from floor
- *B* Terrazzo shower tray
- *C* Urinal stall
- *D* W.C.
- *E* Manhole or inspection chamber
- *F* Concrete rainwater channel
- *G* 50 mm galv. m.s. or copper waste-pipe
- *H* 32 mm galv. m.s. or copper waste (no trap)
- *J* 100 mm asbestos, pitch-fibre, P.V.C. or stoneware drain

Fig. 4.2 Hepworth vitrified clay dain fittings
- *A* Push-fit flexible socket joint 150 mm to 450 mm internal dia.
- *B* 90° (quarter circle) bend. Sizes 150 mm to 450 mm internal dia.
- *C* 11¼°, 22½° or 45° bend sizes 150 mm to 450 mm internal dia.
- *D* Square junction (Oblique also made)
- *E* Rest bend. 150 mm to 300 mm internal dia.
- *F* Polypropylene coupling. 100 mm and 150 mm dia.

Fig. 4.3 Junction: plastic soil pipe to s.g. pipe
- *A* Plastic adaptor to soil pipe
- *B* Sand-cement joint 2:1

Fig. 4.4 Pitch-fibre pipes and couplings
- *A* Hammer driven joint with p.f. coupling
- *B* Tapered spigot pipe with p.f. coupling, 50 mm to 200 mm internal dia.
- *C* Push-fit, snap ring joint with polypropylene coupling and plain-ended pipes 75 mm to 150 mm internal dia.



DRAINAGE AND SANITATION

the merit of cheapness and simplicity. Experience has enabled authorities to build street culverts of adequate size, frequently in excess of the capacities of normal pipes. These are mainly fed from open concrete channels from the surrounding areas and buildings and carry both rain-water and waste water from sinks, baths, etc. The method is satisfactory provided that the water is adequately disposed of and the branch channels cleaned out frequently. Drain sweepers are part of the regular staff in many institutions. Unfortunately, the besom or local broom used has a tendency to take the surface off the rendering making it less hygienic and harder to clean. Sodium silicate, as described for floors in Volume 1, would help in these cases to harden the surfaces.

Combined rain- and waste-water channels are permitted by a number of tropical sanitary authorities, provided this is discharged into a stream or soakaway and kept out of soil drains and sewers. Figure 4.1 shows this arrangement where the shower and wash-basin wastes both discharge into an open channel, while the urinal and w.c. wastes are connected to a manhole or inspection chamber.

SOAKAWAYS. For a description of these see *Septic tanks* and also Volume 3. Tests should be made to ensure that the ground is sufficiently porous for the soakaways to function properly. It should not be overloaded, causing the surrounding ground to become swampy.

PIPES. The materials used for foul-water drains are chiefly *asbestos cement*, P.V.C., and *pitch-fibre*. The first is very common because of it is cheap and easy to lay. Pitch-fibre and plastics are superior in that they are tougher, flexible, and easily jointed, Fig. 4.4. They are, however, more expensive.

Where good-quality *salt-glazed stoneware* pipes can be manufactured locally, they tend to be used exclusively otherwise not at all because of the expense of transport. Glazed vitrified clay (G.V.C.) with polypropylene couplings and or self-aligning seals and push-fit joints are now widely used in many countries. A number of the more common bends and junctions are shown in Fig. 4.2. An excellent drainage handbook giving full details is published by the Hepworth Iron Company, England.

Cast iron pipes are used only for important or special work and are now rare in the tropics.

Pitch fibre pipes are normally manufactured in sizes from 75 mm to 150 mm in diameter and up to 3 m in length. Jointing is effected either by push fit as shown in Fig. 4.4c or by driving a loose tapered sleeve on to the end of an existing pipe, no jointing compound being necessary, Figs. 4.4 *A* and *B*. Cutting to required lengths is easily carried out and pipe ends can be tapered on site by means of a special tool. The pipe may be joined to other material with cement/sand 1:1 and tarred yarn gaskin. Double collars are available for jointing two plain-ended pipes with a cement joint.

Although jointing by driving is still done, the method illustrated in Fig. 4.4c is now taking over. The rubber snap ring is simply slipped over the end of the pipe and the coupling pushed into position by hand. Alternatively the pipe itself can be pushed into the coupling. But, as with all imported materials, the builder or architect is advised to check on the supply position, including accessories, before committing himself.

Asbestos cement fibre pipes are still popular and can be supplied in lengths up to 6 m. They are made in various weights and diameters but are rather inflexible and precautions have to be taken in handling and laying. A full range of radius bends is made. Jointing of plain pipes with snap rings is now usual, as illustrated in Volume 3.

For domestic and small-scale building 100 mm pipes are usually satisfactory, but when dealing with larger buildings the sizes may need to be calculated. For instance, a disposal of 180 litre of soil water per person per day with a peak flow of 45 litre maximum through a 100 mm pipe at a gradient of 1:40 will give a discharge of 630 litre/min., which is sufficient for fourteen people. Tables are available giving such data. The usual fall for drain-pipes is given in Volume 3. Where the available fall is less than that stated, then pumping may be necessary. Increasing the diameter of the pipe is not to be recommended as a small pipe gives a better cleansing velocity than a large one.

Precast concrete pipes can be quite effective when properly manufactured to produce a dense concrete usually by hydraulic pressure. They are made in sizes up to 1 m in diameter and are suitable for main drainage or water supply. Many drainage accessories are made of precast concrete including circular manholes, septic tanks, gully traps, concrete covers, and paving slabs.

MANHOLES. These should be inserted in a drainage pipeline between the building and the point of discharge into the sewer or septic tank, as in Fig. 4.5. They should not be more than 30 m apart. The manhole connecting the two w.c.s and a urinal is shown in Fig. 4.1 and enlarged in Fig. 4.6. Where single junctions occur inspection chambers are not usually required, though this should be checked with the local authority.

The pipes discharging into inspection chambers should be arranged to permit maximum flow. It is a good plan where possible to cut the asbestos or fibre pipe as at *A* to form a channel and arrange for steeply benched channels to be formed in concrete. Sometimes special channels of stoneware are available for this purpose. The rodding eye *C* has been adapted from a standard pitch-fibre bend: curved bends, however, are available and further examples are given in Volume 3.

Setting out to falls. The simplest method of laying pipes to a gradient is by means of *sight rails* and *boning rods*, Fig. 4.8. A level line may be sighted through on to a vertical rod at *C* and the calculated fall marked down to give the height of the lower rail, 1 m in this case. Alternatively, the fall may be worked out for 3 m as at *E*, which is 75 mm for 1 in 40, to give the gradient direct. A new boning rod is then made, the height of which is from the sight rail to the drain invert. This is then used to obtain the slope of the trench in which the pipes are laid. Hand holes may be formed in the trench bottom under each socket to allow the pipe to rest evenly in the trench and to allow for joining.

Testing. When laying has been completed, some authorities require drains to be tested. This may be done by sealing the ends with either a sealing plug *A*, Fig. 4.7, at the top end and a flexible bag stopper or plug *C* at the other. The pipes can then be filled with water or smoke and the loss of head or pressure noted after a short lapse. This test is not often demanded in warm countries.

SEPTIC TANKS. These are in wide use, particularly where a main sewage system is inadequate or non-existent. The principle is very simple. The discharge enters the inspection chamber and passes into the septic tank through a tee junction. A crust forms on the surface of the liquid. This seals off the air at the surface and enables anaerobic bacteria to render the sewage harmless, turning it into sludge which collects at the bottom of the tank. The sludge may be removed at intervals and used as manure. The liquid on the right of the baffle passes into a soakaway

Septic tank

Fig. 4.5 Septic tank
A Half-round channel
B Tee junctions
C 100 mm vent pipe
D Broken stone, graded if possible
E Septic tank bottom. Fall 1 in 20
F 50 mm concrete baffle
G Usually 600 mm

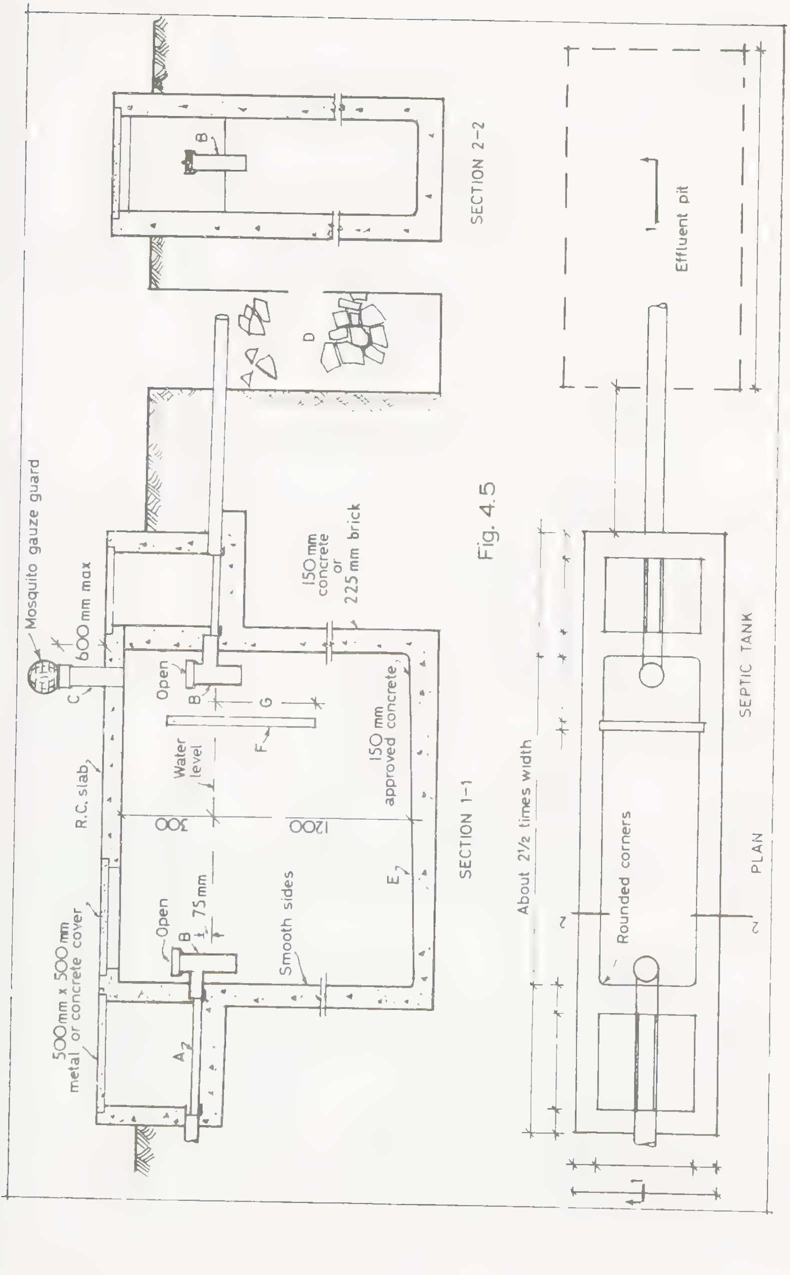

Mosquito gauze guard
600 mm max
C
R.C. slab
500 mm x 500 mm metal or concrete cover
A
Open
B
75 mm
Smooth sides
Open
B
G
F
Water level
300
1200
E
150 mm approved concrete
150 mm concrete or 225 mm brick
D
SECTION 1–1
SECTION 2–2
B
About 2½ times width
Rounded corners
2
2
1
1
SEPTIC TANK
PLAN
Effluent pit

Fig. 4.5

Manholes and gullies

Fig. 4.6 Manhole details
A Pitch-fibre or asbestos cut pipe to form channel
B Concrete benching and branch channel
C Pitch-fibre junction as rodding eye
D 150 mm concrete or 225 mm brickwork
E Precast concrete slabs 63 mm thick
F 150 mm concrete slab

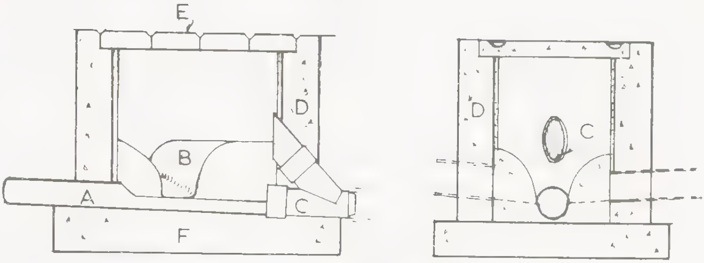
Fig. 4.7 Drain testing plug
A Sketch of plug
B Section through plug
C Flexible bag stopper with brass pump

Fig. 4.8 Setting out drains
D Top sight rail
C Bottom sight rail
E Boning peg
F Boning rod made to measure

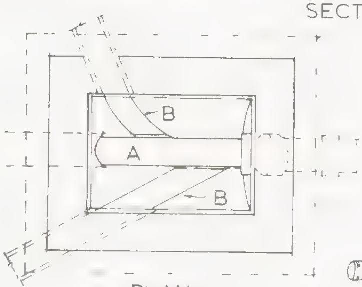
Fig. 4.9 S.G. ware grease trap
D x E 300 mm × 300 mm to 600 mm × 450 mm
H 300 mm to 400 mm
J Galvanized perforated tray
K Cast iron cover

Fig. 4.10 S.G. square gully
A 317 mm (but see Vol. 3)
B 215 mm
C 63 mm
D 390 mm

Fig. 4.11 Sketch of angle gully



SECTIONS



PLAN

Fig. 4.6

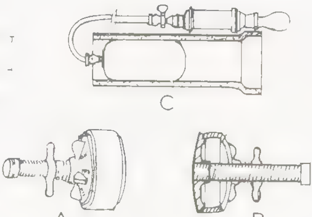


Fig. 4 7

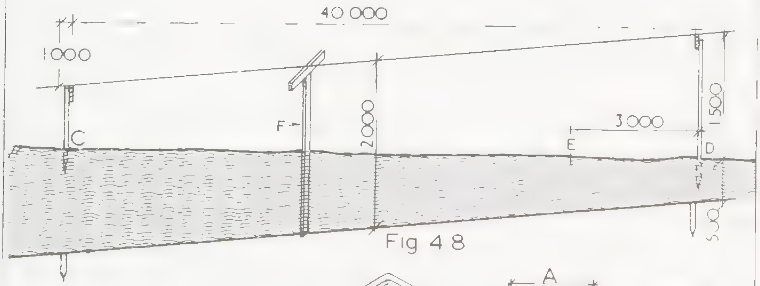


Fig 4 8

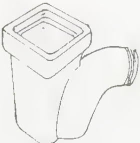


Fig. 4.11

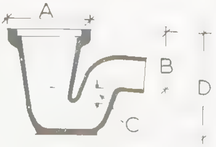


Fig. 4.10

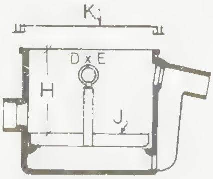


Fig 4.9

MANHOLES and GULLIES

pit where it seeps into the surrounding ground. The pit should preferably be filled with graded stone, largest at the bottom, although this depends on the supply. Some authorities insist on a properly constructed filter bed with masonry walls, but practice varies with population, local conditions, proximity of wells and drinking water. The source of the latter should be at least 50 m from the tank. More elaborate units are often constructed sometimes with mechanical filters, see Volume 3.

CESSPOOLS. A common if unpleasant method of sewage disposal is by means of a cesspool. This consists of a watertight pit, usually circular in shape, the size depending on the amount of use. It is emptied at regular intervals, say once a month. A modern sewage vehicle with a mechanical pump can empty it quickly and efficiently, otherwise it can be objectionable. Sometimes the bottom is perforated so that the liquid can seep away. Cesspools, however, are insanitary and a septic tank is to be preferred.

SOIL-STACKS. Ground floor w.c.s and other appliances may discharge direct into an inspection chamber, as shown in Fig. 4.1. Sanitary appliances on upper floors, however, discharge first into a soil-stack which is connected, via a branch drain, direct to the inspection chamber. These soil-stacks are usually 100 mm in diameter and are normally of pitch-fibre, asbestos cement fibre, plastic, or vitreous enamelled m.s. Where appliances can be grouped reasonably close to the soil-stack, a single-stack system of drainage may be used. This is shown on plan in Fig. 4.12 and the stack with branches in Fig. 4.13. It is normally taken above the roof level and left open for ventilation. A guard *A* is placed over the top to prevent the ingress of birds and insects. It will be noticed that the bath, wash basin, showers, etc. discharge directly into the stack. In order to prevent unpleasant smells from entering the bathroom, special deep-seal traps are placed directly beneath the waste pipe inlet, Figs. 4.31 and 4.32. The 75 mm water seal is necessary to prevent the water in the trap from being sucked out by siphonage, usually greatest when the cistern is being flushed. Alternatively the bath, sink, and shower may discharge direct into a hopper head *K*, Fig. 4.37, which is part of the rainwater downpipe system. W.C. branches as shown in *L*, Fig. 4.13, are normally placed below those waste fittings *F* and *J* in order to reduce siphonic action.

Another system of drainage known as the 'one pipe' system is used where it is not possible to group appliances together. In this case each bath, basin, and sink needs to be ventilated (see Vol. 3). This sometimes leads to complicated plumbing arrangements at floor levels in order to fit all junctions into the soil stack. For this reason every effort should be made in the design stage to adopt the single stack system.

The stack shown in Fig. 4.13 is in P.V.C. Similar joints are obtained with vitreous enamelled steel. Where plastics are used, they should not be exposed to direct sunlight and it is better to place them inside the building as in Fig. 4.12. Figure 4.14 shows a P.V.C. asbestos connection and Fig. 4.15 a P.V.C. pitch-fibre joint. Three methods of connecting the w.c. pan to a P.V.C. socket are shown. *N* shows a P.V.C. adaptor to fit between the w.c. outlet and P.V.C. socket. A second method shows a ring at *O*; after fixing, the socket is heated, when it may be moulded around the ring as at *P*. A third method is the normal cement/sand/gaskin joint as at *Q*. See also Fig. 4.20.

The fixing of soil stacks in P.V.C. needs to be done with flexible joints, because of its high rate of expansion. The joint shown in Fig. 4.16 allows for this movement. The strap *B* hooks into the saddle on one side and is bolted on the other.

4.3 Sanitary ware

Flushing cisterns to w.c.s and urinals are made in many patterns and materials. They are normally of 9 litre capacity for single w.c. pans and designed to discharge their contents in 5 seconds. Cisterns are usually *high-level* or *low-level* and the action is performed by starting a siphon. Low-level cisterns are normally of either ceramic or plastic, Fig. 4.17. If ceramic, the non-moving parts are usually plastic with brass fittings. The act of raising the lever *J* causes the plate *F* to rise, splashing water into the pipe *B*. The disc *F* returns by gravity, water entering through the hinged flap *G*.

Water coming into the cistern is regulated by means of a 'Portsmouth' valve, Fig. 4.18, and ball float. The action of the valve is self-explanatory. Flushing cisterns should be connected to storage tanks, Fig. 4.24, and not direct to mains, otherwise the high pressure of water on the inlet washer *C* is apt to cause rapid wear.

In hot dry climates or where dry seasons make the use of flushing cisterns wasteful, two devices are obtainable to help to save water. The first is a dual-flush cistern whereby only half the total water is released when the handle is pushed down half way. This is normally sufficient for the disposal of urine or waste water. A full 9 litre flush is used only when essential. The second method is the vacuum sewerage system whereby the soil water known as 'black water' -pipe is held under constant vacuum of about half atmospheric pressure. Such a system, however, requires a patented water closet and special valve mechanism and would only be advisable in areas where a high standard

Continued on page 126

P.V.C. soil pipes

Fig. 4.12 Bathroom with wah-basin and w.c.
A Bath or shower tray
B Wash-basin
C W.C.
D 38 mm copper or plastic waste to bath
E 32 mm basin waste
F *S* trap to w.c.
G Plastic soil stack

Fig. 4.13 Vinyl soil stack to two-storey houses
A Vent terminal
B Flexible plastic slate cap
C Lead slate
D 100 mm vinyl pipe
E Single 38 mm/32 mm boss branch 92½° with tail
F 32 mm copper waste to basin
G Neoprene adaptor 38 mm to 32 mm
H As *E* without tail
J 38 mm copper bath or shower waste
K 95° branch
L Bent w.c. connector 95°
M Tail or w.c. trap
N P.V.C. adaptor
O Shrunk O ring joint to w.c. before heating
P Shrunk O ring joint to w.c. after heating
Q Mastic and gaskin joint
R Pipe; double spigot 2 m long
S As *H*
T Pipe with O ring socket 450 mm long
U Vinyl drain adaptor
V S.G. drain socket
W Sand and cement joint 2:1 with gaskin

Fig. 4.14 P.V.C. asbestos connexion
A 100 mm asbestos soil pipe
B Vinyl adaptor for flat roof
C Asbestos cement and gaskin joint
D 100 mm in neoprene O ring
E 100 mm vinyl soil pipe
F 100 mm asbestos soil pipe with socket

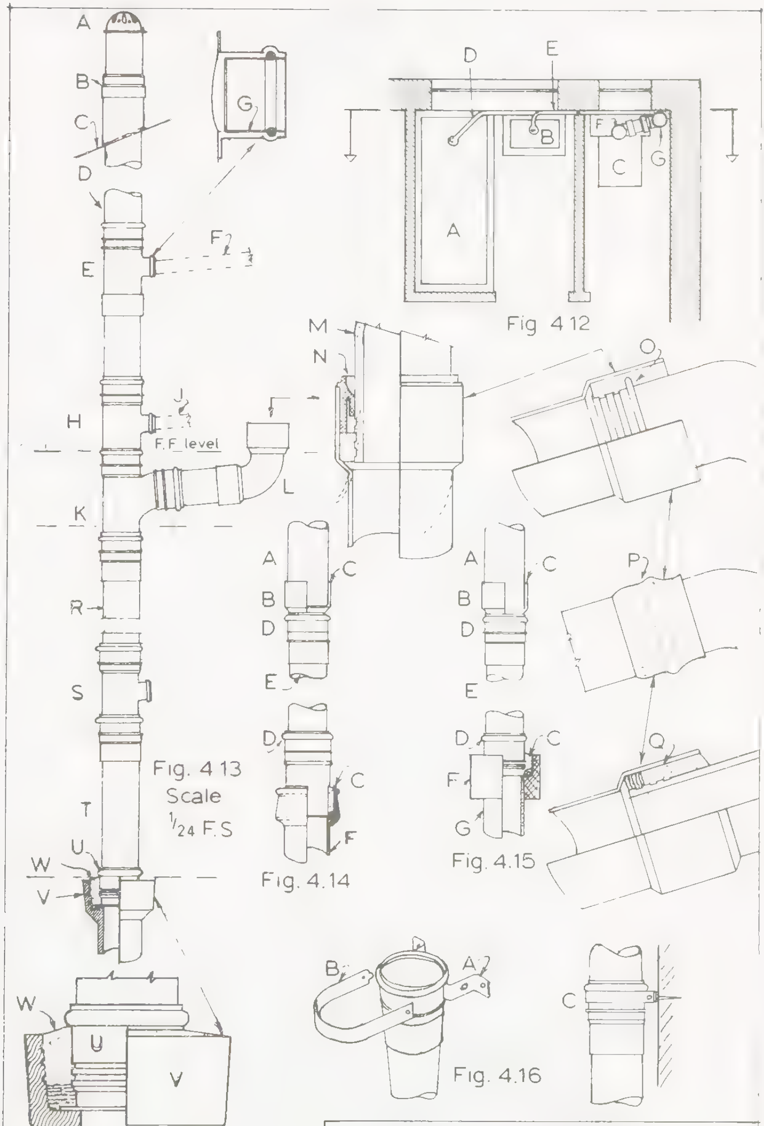


Fig 4.12

Fig. 4.13 Scale $^1/_{24}$ F.S

Fig. 4.14

Fig. 4.15

Fig. 4.16

P V C. SOIL PIPES

Fig. 4.15 Pitch-fibre/P.V.C. connexion

A 100 mm pitch-fibre pipe
B As above (Fig. 4.14)
C All as Fig. 4.14
D All as Fig. 4.14
E All as Fig. 4.14
F Pitch-fibre pan adaptor; drive-on taper
G Pitch-fibre drive-on taper joint

Fig. 4.16 Vinyl soil pipe fixing

A P.V.C. coated m.s. saddle
B P.V.C. coated m.s. pipe strap hooked on one side, screwed on other
C Soil pipe in position

W.C.s and cisterns

Fig. 4.17 Low-level flushing cistern

A Ceramic or plastic cistern
B Siphon pipe
C Plastic, brass or copper ball valve
D Overflow or warning pipe
E Inlet to 'Croydon' or 'Portsmouth' valve
F Disc
G Flap
H 38 mm flush pipe
J Lever mechanism
K Brass wire link

Fig. 4.18 'Portsmouth' valve

A Ball valve arm
B Pivot
C Rubber or fabric washer
D Valve seating
E Valve slide
F Cap

Fig. 4.19 Wash down w.c.

A 9 litre plastic low-level cistern
B Standard vitreous china wash down w.c.
C *P* or *S* trap. Side or back exit
D Side overflow (or concealed as D1)
E Side supply (or bottom as E1)

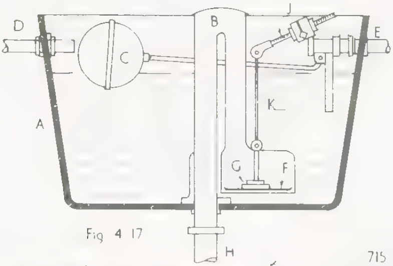


Fig 4 17

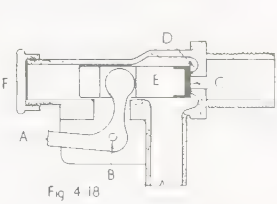


Fig 4 18

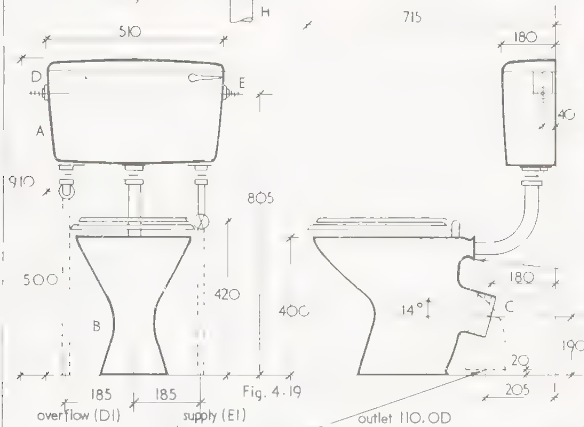


Fig. 4.19

outlet 110.OD

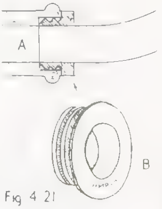
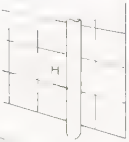
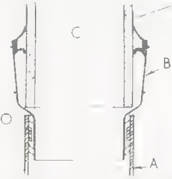


Fig 4 21





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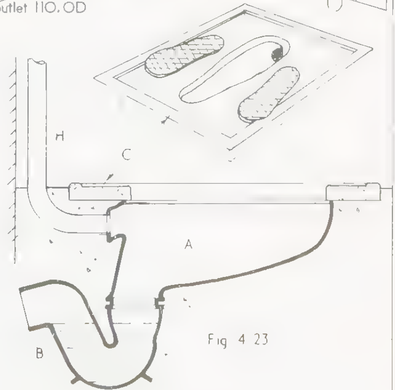


Fig 4 23

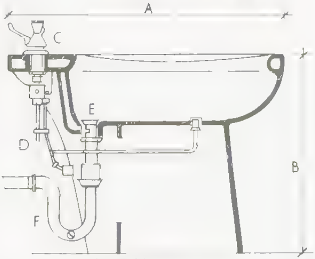


Fig 4 22

W C s and CISTERNS

Fig. 4.20 Flexible plastic w.c. outlet connector
- *A* Soil pipe
- *B* Outlet connector
- *C*, *P* or *S* trap outlet

Fig. 4.21 Rubber inlet connexion
- *A* Section through inlet to pan
- *B* Sketch of rubber connexion (4 sizes)

Fig. 4.22 Vitreous china bidet
- *A* 660 mm
- *B* 400 mm
- *C* 13 mm h. & c. (if necessary) taps with transfer valve to rim or douche
- *D* 13 mm copper supply pipes
- *E* 32 mm pop-up waste
- *F* 32 mm P trap

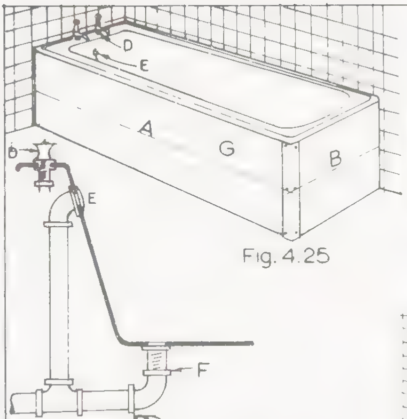
Fig. 4.23 Vitreous china squatting w.c.
- *A* 500 mm × 330 mm pan
- *B* Loose S or P trap
- *C* Fireclay squatting plate
- *H* 38 mm flush pipe

Sanitary appliances

Fig. 4.24 Polyethylene cold water tank. Capacity 45 to 450 litre
- *A* Plastic ball valve
- *B* High-pressure inlet valve
- *C* Overflow

Fig. 4.25 Cast-iron porcelain enamelled or Perspex bath
- *A* 1530 mm
- *B* 685 mm
- *C* 495 mm
- *D* Chromium plated (c.p.) 19 mm pillar taps
- *E* 32 mm overflow
- *F* 38 mm waste with plug and chain, and brass P trap if required
- *G* Panelling (*see* Interior Finishes)

Fig. 4.26 Vitreous china wall urinal
- *A* Urinal: size 380 mm × 320 mm × 600 mm high
- *B* Dividers 150 mm × 320 mm × 600 mm high
- *H* 32 mm vertical waste pipes



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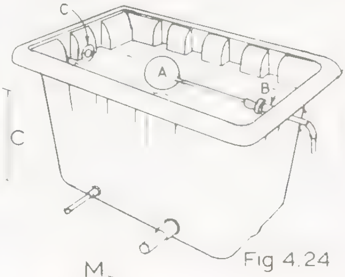


Fig 4.24

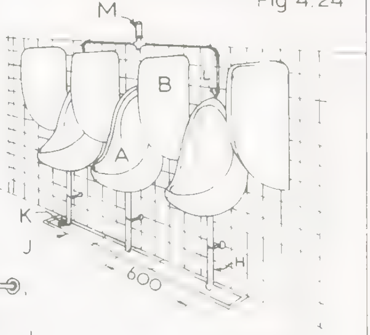
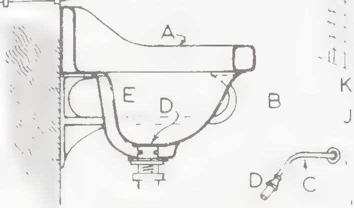


Fig. 4.26



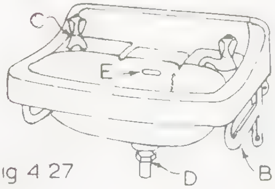
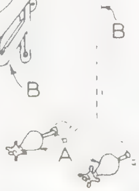


Fig 4.27



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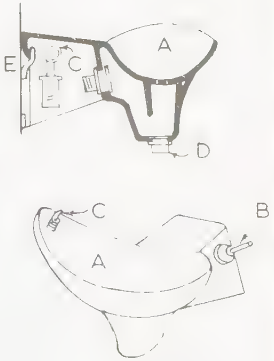


Fig. 4.28

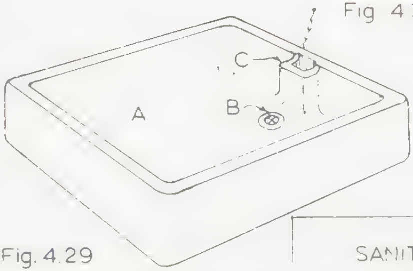


Fig. 4.29

SANITARY APPLIANCES

of maintenance could be relied upon. The annual saving of water per person could be in the region of 23 000 to 43 000 litres, very desirable where main drainage has not been installed or where water is in limited supply.

WATER CLOSETS. These are supplied in a variety of patterns and colours. They are made of vitreous china, usually with seats of hardwood or coloured plastic. Figure 4.19 shows a typical w.c. with a 50 mm water seal. Traps, either *P* or *S*, can be supplied with left- or right-hand discharge as well as at the rear as shown.

Fig. 4.26 (cont'd)
J 150 mm white fireclay block channel with stop ends
K 50 mm outlet strainer with metal dome
L C.P. spreaders and 32 mm c.p. spud outlet
M 32 mm flush pipe from automatic cistern

Fig. 4.27 Vitreous china wash-basin
A Basin; size 500 mm × 400 mm
B Towel rail enamelled cast-iron brackets (or pedestal if desired)
C 13 mm c.p. taps
D 32 mm plug waste
E Overflow

Fig. 4.28 Vitreous china drinking fountain
A Fountain basin size 340 mm × 320 mm
B Self-closing tap
C Jet with lip guard
D 19 mm outlet
E Wall hanger

Fig. 4.29 White glazed fireclay shower tray
A 760 mm × 760 mm tray (3 sizes available)
B 38 mm waste plug and chain
C Overflow

Fig. 4.30 Shower fittings
A 13 mm h. & c. taps (or cold only)
B Concealed riser pipe
C Angle shower arm
D Atomizer spray head with ball joint

Squatting w.c. pans, Fig. 4.23, are also used in many countries. The fireclay squatting plate *C* is usually separate from the pan *A*. The trap *B* is also separate so that it may be fixed at any required angle. High, low or medium level cisterns are used as preferred.

Bidets are now fairly popular in hospitals, hotels, and residences particularly in women's toilets. They may also be used as footbaths. No flushing cistern is necessary as all supply pipes and stopcocks are delivered with the fitting. Hot water may be needed in some areas and two taps are usually provided. Bidets are also useful in areas of low rainfall where water needs to be conserved.

SHOWERS. Showers are very popular in the tropics as they are quick to use and to install, they also take up less space than baths. Complete cabinets including trays are supplied by some manufacturers. These are constructed of anodized aluminium walls with terrazzo floor trays. Doors or curtains may be provided as required. Floor trays can be made of many materials. A popular one is still white glazed fireclay, Fig. 4.29. Chromium-plated curtain rails with plastic curtains are still more popular than cabinets as they are cheaper and easier to install.

BATHS. Though not as widely used as showers, baths are available, and range from inexpensive acrylics to porcelain enamelled bath suites with matched fittings. A usual type is shown in Fig. 4.25. This has adjustable feet, and front and end panels of termite-proof enamelled hardboard. Coloured glass, plastic, or built-in tiled panels are also available. Where the latter are used, an access cover to the plumbing must be provided. Baths are usually supplied in sizes from 1360 mm to 1820 mm long and 660 mm to 710 mm wide, with 19 mm taps, 38 mm waste, and 32 mm overflow.

Plastic baths, complete with flexible P.V.C. pipes and waste traps, are now widely used. These require a rigid bath cradle as plastic lacks stability, but they are light and cheaper than cast iron. When ordering, the position of the bath should always be stated in order that the fittings may be supplied to the correct hand.

SINKS. Ceramic glazed fireclay is still in use today, although stainless steel and enamelled steel are superseding it. Some sinks, particularly stainless-steel ones, incorporate draining boards as well, (see answer to Ex. 4.1c). There is a wide range and the reader is advised to consult makers' catalogues where possible. For everyday kitchen or washhouse use, the usual ceramic sink is the 'Belfast' size 610 × 460 × 250 mm deep. It should not be fixed higher than 800 mm above the floor to allow for the addition of a draining board or worktop if required.

WASH-BASINS. A wide variety of modern designs are now available either as part of bathroom suites or as individual units, and in a full range of materials. A plain standard pattern in vitreous china is shown in Fig. 4.27. Pedestals may be supplied in lieu of brackets for many designs. Vanitory units constructed in a similar manner to that shown in the answer to Ex. 4.1c, with hard plastic surrounds in matching colours, are a regular feature in hotel cloakrooms and bedrooms as well as in residences.

For general use, however, the usual sizes range from 600 × 430 mm to 700 × 500 mm and are fitted with 13 mm hot and cold taps and 32 mm waste. Traps to baths, wash-basins, sinks, etc., are not always fitted if they discharge into open channels. Basins should be fitted about 820 mm from the floor.

URINALS. Two types are popular today, usually made of S.S., vitreous china or fireclay. The first, a stall slab consisting of a flat slab with a white glazed half round block channel, is set in at floor level and fitted with stop ends complete with a strainer outlet and a metal dome. The second, the *wall type*, is popular in public and office building, Fig. 4.26. It may be supplied with or without divisions. The vertical waste in this case discharges into block channels as before. This method is simple, direct, and very clean. The urinal is flushed by an automatic flushing cistern. Plain S.S. stalls, with or without divisions, are also in demand.

DRINKING FOUNTAINS. A typical example, as used in schools, institutions, and elsewhere, is shown in Fig. 4.28. It is made of vitreous china with a self-closing tap, jet, and lip guard. The pressure can be regulated as desired. It is supplied complete with 19 mm outlet and wall hanger.

COLD WATER SUPPLY. Sources of water in tropical countries are numerous rivers, wells, ponds, streams, and large rain-water storage tanks. The latter are in wide use today, even in modern complexes. Piped supplies are usually the responsibility of the water authority rather than the local council; meters are often inserted at the mains where branch pipes are taken off and a stopcock fixed at this point. Water at mains pressure enters the building via a *rising main* and it can supply a cold water storage tank direct, Fig. 4.24. Main supply is, in addition, usually taken direct to the kitchen and other taps and also to drinking fountains, etc.

Cold water cisterns are compulsory in some areas. For domestic purposes they are usually of 250 litre capacity and allow for storage in case of breakdown, particularly where cut-offs are fairly frequent. Most large institutions have their own high storage tanks installed to regulate supplies.

Water consumption is difficult to estimate. Factories, sports pavilions, hotels, etc., could use the following quantities daily, depending on their size:

Shower	450 litres
w.c.	180 litres
Basin	90 litres
Yard tap	180 litres
Urinal	180 litres
Bath	450 litres

Domestic consumption is usually much less, while some factories may often require more. The water company can usually help with average figures.

4.4 Materials

Cold water cisterns may be of P.V.C., either circular or rectangular, galvanized iron, copper, or m.s. Asbestos cement fibre tanks may also be imported.

Internal supply and distribution pipes are mainly copper, with P.V.C. reserved for cold water only. Copper may be used for the whole of the water service, including underground and rising main. It will stand pressure up to 150 m head. Pipes are supplied in diameters from 10 mm to 100 mm and in three weights for some sizes; the heaviest are for use below ground, the medium-weight ones for standard light gauge tube and the lightest, for sanitation work.

Jointing is normally carried out by two methods: *compression fitting* and *capillary joint*. The first is shown in *C*, Fig. 4.34. A tapered ring of copper is slipped loosely over the pipe and the fly nut tightened, causing the ring to be compressed. Joints in this category may be manipulative, *A*, Fig. 4.34, or non-manipulative, *H*, Fig. 4.34. The former has its end *B* manipulated, i.e. dilated before the fly-nut *D* is tightened.

Capillary joints need heat to seal the joint. A ring of solder, *B*, Fig. 4.33, is inserted at manufacture into the ring fitting. To make the joint, the end of the pipe *C* is cleaned and fluxed, then pushed into position. Heat applied to the fitting causes the solder *B* to run and fill the joint. All the above can be made without much skill, provided that a few basic precautions are observed. Elbow bends, tees, and crosses are available to simplify assembly. A copper union for use with capillary joints is shown in Fig. 4.35.

Polythene pipe for cold water services is now widely used, and two methods of jointing are shown. One, Fig. 4.36, shows a typical cone and collared pipe *A* jointed to fitting *B* by means of a threaded fly-nut *C*. The second method is as shown in *E*, Fig. 4.34, where a compression joint is used in conjunction with a copper liner *G*.

Traps. Two types of trap are shown for use with shower baths, sinks, basins, etc., where the single stack system of plumbing is used. Figure 4.31 shows a bottle trap either in brass or plastic and is secured to the waste outlet by a fly-nut *E*. It has a 76 mm seal.

Figure 4.32 is in brass and incorporates the solder ring principle. In order to adjust it to the required height, sleeve *B* telescopes into *A* and may be fixed permanently by heating as described. The tail of the trap shows a union but may also be supplied with spigot *F* in which case the connection to waste would be permanent.

4.5 Hot water supply

For domestic installations and medium-sized buildings, water heating is normally done by electricity. It has the advantage of being clean and, where the amount of water used is not excessive, highly efficient.

Cistern-type heaters are the most popular. They can be installed easily and are made in a range of sizes which will store from 20 to 200 litres of hot water. A 70 to 100 litre capacity heater is usually suitable for a small house and will operate from a 13 A socket outlet. Water is supplied from either the mains supply or a storage tank. Small sink units are also in demand where only one outlet is needed. Larger installations supply kitchen sink, bath, and wash-basin. In this case it is essential that all the outlets be placed close together to avoid long runs which would waste hot water. Where this happens, it is cheaper to install separate unit heaters to supply single outlets.

Industrial heaters can supply up to 454 litres with a loading of 18 kW. An automatic hot water service can also be installed by inserting a thermostatically-controlled immersion heater into an existing tank useful for districts which have recently been supplied with electricity.

RAIN-WATER DISPOSAL. The most common method of rain-water disposal for small and medium-sized buildings and where roof gutters are not permitted is to cause the water to cascade into a shallow ground channel. The channel could then lead either to a soakaway, a stream or to open ground at a lower level. Channels should be wide enough to collect roof run-off during heavy rains. It is common practice for builders to lay an apron of concrete around the run-off sides with a narrow channel at the outside edge. Aprons must be wide enough to prevent erosion taking place at the outside edge of the channel during heavy rains. Concrete channels are normally about 150 mm to 230 mm wide to allow for cleaning. Where by-laws permit, sinks, baths, etc., also discharge into them.

Should rain-water be required or permitted to discharge into the soil drain, the entrance to the soil pipe needs to be suitably trapped. A typical trap of stoneware is shown in Fig. 4.10. These are made in a wide range of sizes to suit particular needs, (see Vol. 3). Wastes from hotel and institution sinks are sometimes connected to a grease trap, Fig. 4.9, whether discharging into soil pipe or surface channel. The tray *J* is removed at regular intervals for cleaning. With the extensive use of detergents in most countries, however, the use of grease traps is diminishing.

Where roof water needs to be collected into tanks and/or when dropping run-off is undesirable, rain-water gutters may be provided, as in Fig. 4.37. It may be necessary to ascertain whether their use is permitted, as poorly fitted gutters can provide a breeding place for mosquitoes.

R.W.G.s and downpipes are now made in a variety of materials with accessories to match, some of which are shown here. Vitreous enamel, m.s., and plastics are all in general use. Steel pipes need jointing compound at each joint, but plastic fittings are supplied with cushions or waterproof seatings which enable the r.w.g.s to be clipped into position easily. The system of assembly is similar to that shown for soil stack, Fig. 4.13. Flexible joints are necessary to allow for expansion and the type of strap shown in *F*, Fig. 4.37, is simple and effective.

In hot climates plastics should not be exposed to the sun; but as improvements are constantly being made in heat-resisting plastics, manufacturers' advice should be sought before decisions are taken. A good plan is to obtain a sample length, leave it assembled in the sun for as long as possible, and then examine it for defects.

Drainage to flat roofs and balconies needs a special type of outlet, three examples of these are shown here. For small roofs and balconies the one shown in Fig. 4.38 is suitable. It is made of pressed steel,

Continued on page 136

Traps and pipe connexions

Fig. 4.31 Basin waste and trap
- *A* Wash-basin
- *B* 32 mm to 38 mm brass waste outlet
- *C* Fibre, rubber or leather washer
- *D* Back nut
- *E* Coupling nut
- *F* Brass or high density plastic bottle trap
- *G* Adaptable outlet for plastic or copper
- *H* Removable base for cleaning

Fig. 4.32 Brass union P trap
- *A* 32 mm to 38 mm trap
- *B* Adjustable extension piece
- *C* Inspection eye
- *D* 76 mm seal
- *E* Union outlet
- *F* Alternative to *E*
- *G* Solder strip for capillary joint

Fig. 4.33 Copper; straight coupling
Sizes 3 mm to 64 mm *dia.*
- *B* Solder capillary ring
- *C* Copper tube to be jointed

Fig. 4.34 Tee junction–compression joint
- A Manipulative fitting
  - *B* Copper pipe
  - *C* Copper wedge ring
  - *D* Brass fly nut
- E Polythene pipe joint
  - *F* Polythene pipe
  - *G* Copper liner
- H Non-manipulative fitting
  - *J* Brass tee junction

Fig. 4.35 Union connector
Sizes 3 mm to 64 mm *dia.*
- *A* Copper cone sleeve
- *B* Solder ring
- *C* Fly nut

Fig. 4.36 Polythene union connector and junction
- *A* Polythene cone sleeve
- *B* Cross junction
- *C* Polythene fly nut

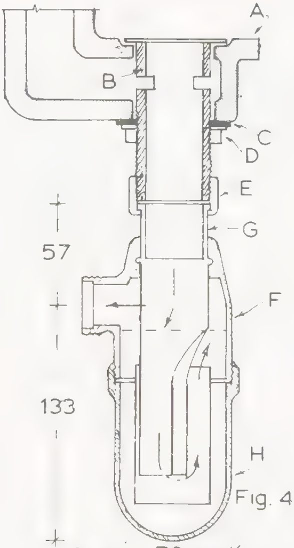


Fig. 4.31

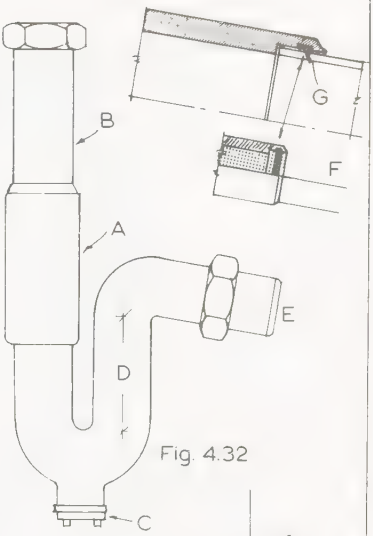


Fig. 4.32

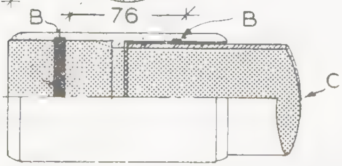


Fig. 4.33

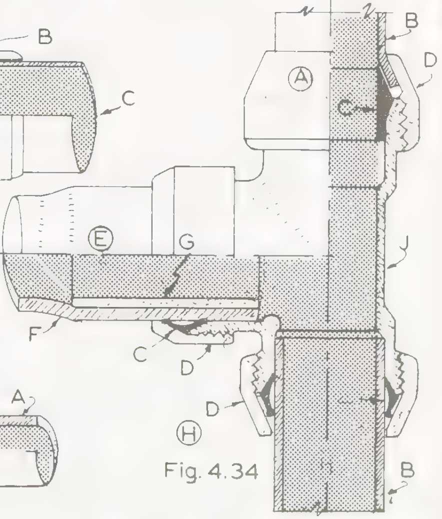


Fig. 4.34

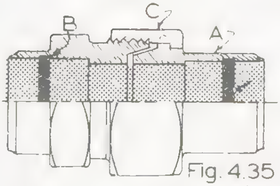


Fig. 4.35

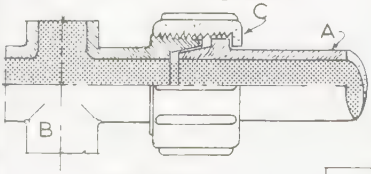


Fig. 4.36

TRAPS and
PIPE CONNECTIONS

Rain-water drainage

Fig. 4.37 P.V.C. rain-water drainage

A Half-round gutter 100 mm bore 4 m long
B Aluminium fascia bracket
C Gutter outlet with nozzle
D Downpipe offset
E 64 mm *dia* downpipe in 2m and 4m lengths
F P.V.C. downpipe clip with m.s. assembly screw
G P.V.C. gutter stop end
H Downpipe connector
J P.V.C. gutter union
K Rain-water head

Fig. 4.38 Vitreous enamelled m.s. drainage

A Roof or balcony outlet
B Concrete roof
C Offset and single branch
(The whole may be purpose-made if required in sufficient numbers)

Fig. 4.39 Cast-iron roof drain

A Dome
B Flashing clamp and gravel stop
C Adjustable collar
D Anchor flange
E Mastic asphaltic filling
F Waterproof finish, gravel covered
G Cement-sand screed
H Insulation
J Concrete roof
K Asbestos, etc., downpipe

Fig. 4.40 Alternative drain for roof decking

L Cast-iron clamping collar
M Brass sleeve
N Roof screeding
O 75 mm to 200 mm *dia.*

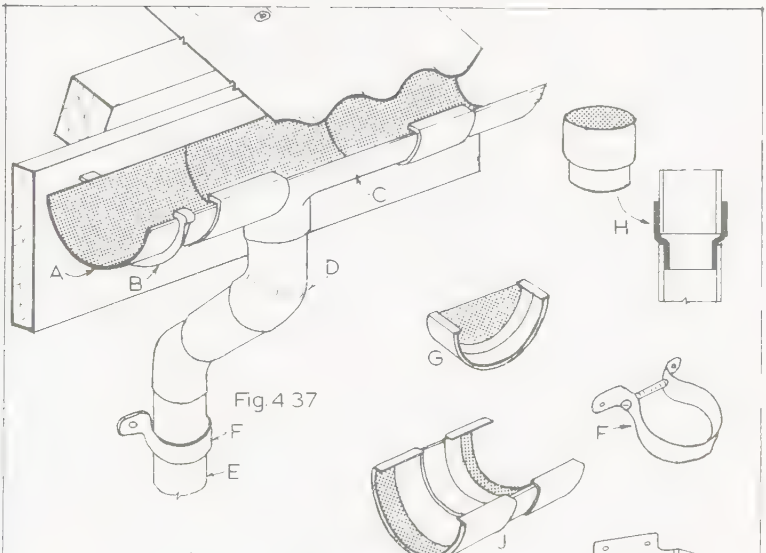
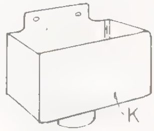


Fig. 4 37



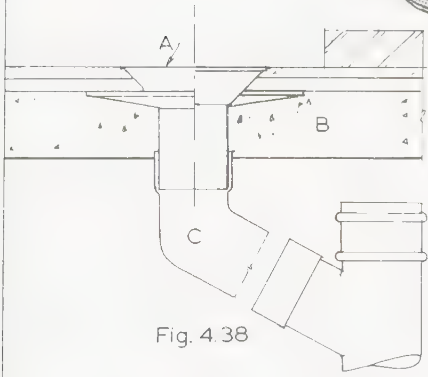


Fig. 4.38

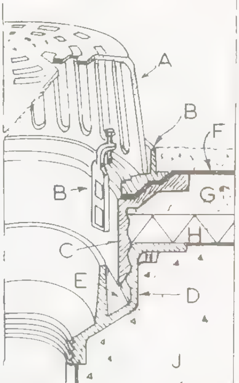


Fig. 4 39

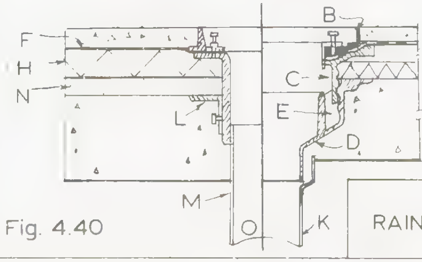


Fig. 4.40

RAIN WATER DRAINAGE

square in plan, in sizes from 230 mm to 330 mm square depending on the size of the pipe (usually from 50 mm to 100 mm, circular or rectangular).

An efficient type of outlet in cast iron is shown in Fig. 4.39. The clamping ring and screw enable the waterproof finish, e.g. felt or asphalt, etc., to fit tightly against the outlet without leaking. The upstand on the clamping ring keeps out the roof gravel and has slots or holes at intervals to drain water into the outlet. The adjustable collar, *C*, allows for correct alignment to roof falls after the body *D* has been built into the roof. After adjustment the socket *E* is caulked with mastic.

Figure 4.40, L.H. section, shows an alternative outlet suitable for a roof decking of steel, concrete, etc. The cast iron clamping collar *L* is positioned as required and the set screw tightened. The clamping ring and screw *B* are fixed as before. Alternative tails or sleeves *M* are provided to suit different downpipes.

Exercise 4.1. Draw an outline plan of the bungalow shown in Fig. 3.23 to any suitable scale. Mark in position the following:

Steward's yard	13 mm mains tap.
Utility	19 mm main supply tap and sink.
Steward's w.c.	Low-level cistern and w.c.
Kitchen	13 mm mains tap, sink and 38 mm waste
Shower	13 mm shower, tray and 38 mm waste
W.C.	*Low-level* cistern suite
Bath	H. & C. 19 mm taps, 38 mm waste
Basin	13 mm h. & c. taps, 32 mm waste

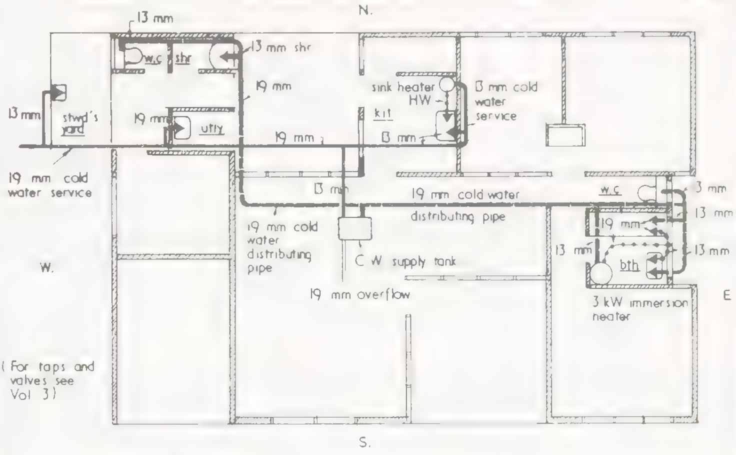
The roof drains from E. to W. and the ground slopes evenly down towards the east.

No concrete channel or apron is permitted on the south side of the house.

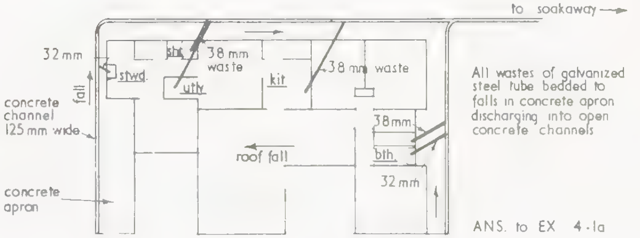
(a) *Draw a line diagram of open channels and aprons which you would propose to drain the roof areas effectively. All baths, sinks and basins may discharge into the channel which drains to a soakaway to the east.*

(b) *Draw a line diagram of the soil disposal system which you propose. A septic tank is situated to the east.*

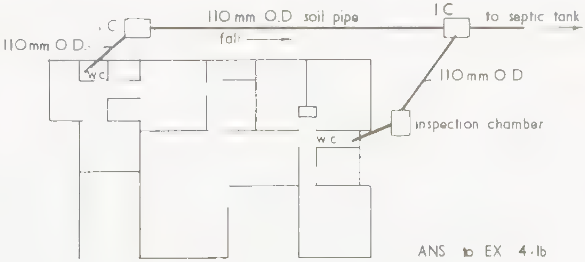
(c) *Draw working details of sinks, baths, and basins in position, clearly enough to enable work to proceed without further reference to you.*



ANSWER TO EXERCISE 4 1

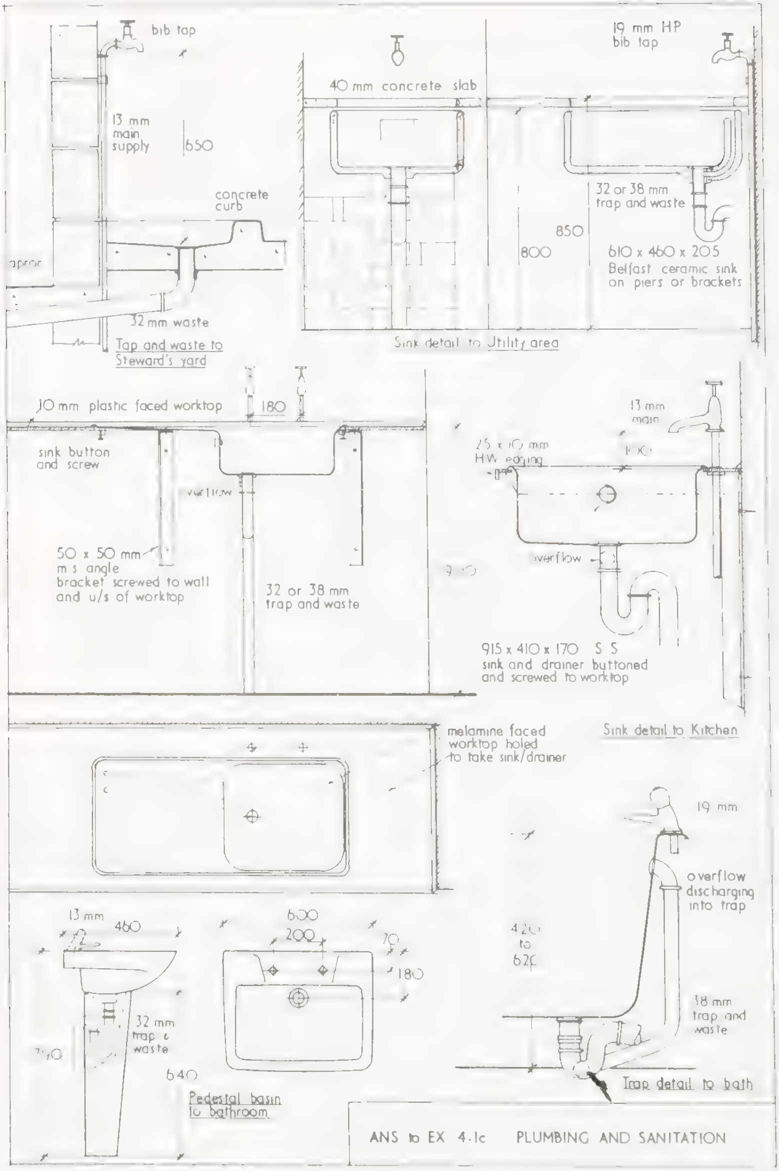

to soakaway
32 mm
shr
38 mm waste
38 mm waste
stwd.
utly
kit
fall
concrete channel 125 mm wide
All wastes of galvanized steel tube bedded to falls in concrete apron discharging into open concrete channels
38 mm
roof fall
bth
32 mm
concrete apron

ANS. to EX 4·1a



ANS to EX 4·1b

PLUMBING AND SANITATION


bib tap
13 mm main supply
650
concrete curb
apron
32 mm waste
Tap and waste to Steward's yard
40 mm concrete slab
19 mm HP bib tap
32 or 38 mm trap and waste
850
800
610 x 460 x 205 Belfast ceramic sink on piers or brackets
Sink detail to Utility area
10 mm plastic faced worktop
180
sink button and screw
overflow
50 x 50 mm m s angle bracket screwed to wall and u/s of worktop
32 or 38 mm trap and waste
13 mm main
25 x 10 mm HW edging
100
900
overflow
915 x 410 x 170 S S sink and drainer buttoned and screwed to worktop
melamine faced worktop holed to take sink/drainer
Sink detail to Kitchen
19 mm
overflow discharging into trap
420 to 620
38 mm trap and waste
Trap detail to bath
13 mm
460
600
200
70
180
32 mm trap & waste
640
Pedestal basin to bathroom

ANS to EX 4.1c PLUMBING AND SANITATION

5 | Miscellaneous Works

5.1 Introduction

In this chapter those items will be included which, although important, do not warrant a separate chapter each. These cover shoring, underpinning, scaffolding, centering, fencing, roads, drives, and footpaths.

5.2 Shoring

Shoring to existing buildings is necessary in the case of faulty foundations, bulging walls in danger of overturning, or where alteration has become necessary. It is not usual in the tropics, partly because older buildings which have become unsafe are not often preserved unless of historical or religious significance. Modernization of fronts, however, sometimes calls for shoring during alterations, and an example of this work is given here.

There are three types of shoring in normal use; *raking, flying,* and *dead shores*. Sometimes a combination of two or more types is necessary for safe support of walls.

RAKING SHORES. Figures 5.1 to 5.5 show a typical detail of a raking shore. The sizes of the members, spacing and angle of the rake are often matters of individual treatment and no hard-and-fast rules can be given. The example shown deals with a fairly common type of earlier tropical building, a part elevation of which can be seen in Fig. 5.6. In this case the obstacle of a veranda has to be overcome. The floors are of wood, which is usual in buildings of this period.

The line of thrust of the raker must be such that it coincides with the centre of support of the floor—in this case the wall plate, Fig. 5.1. It also passes through the intersection of the wall piece and the needle. The rakers pass between the balcony joists and are arranged to avoid the lintel supporting the balcony front. The angle of the raker depends on these factors and also the space available at the front of the building. Where good supplies of timber are available, light-weight hardwood such as Wawa is commonly used. A usual size is about 225 × 225 mm, although smaller sizes may be used for shorter lengths. In order to give greater rigidity, braces *D* of 225 × 25 mm are nailed to the rakers as shown.

A firm base for the system is necessary and the sole plate *E* must be bedded below the ground level. The angle between the outer raker and the sole piece must be a little less than 90° in order for the raker to tighten itself when being levered into position with a crowbar. Heavy hammers should not be used because of possible vibration.

Where long shores are not available, shorter lengths may be used as shown in Fig. 5.5. In this case the outer shore *K* rests on the middle raker *L*, and folding wedges *M* inserted to enable the top portion to be tightened. Alternatively it may be possible to use the existing balcony for partial support, as shown in Fig. 5.3. Care must be taken not to overtighten the system, particularly the outer raker, as it is possible, literally, to raise the roof.

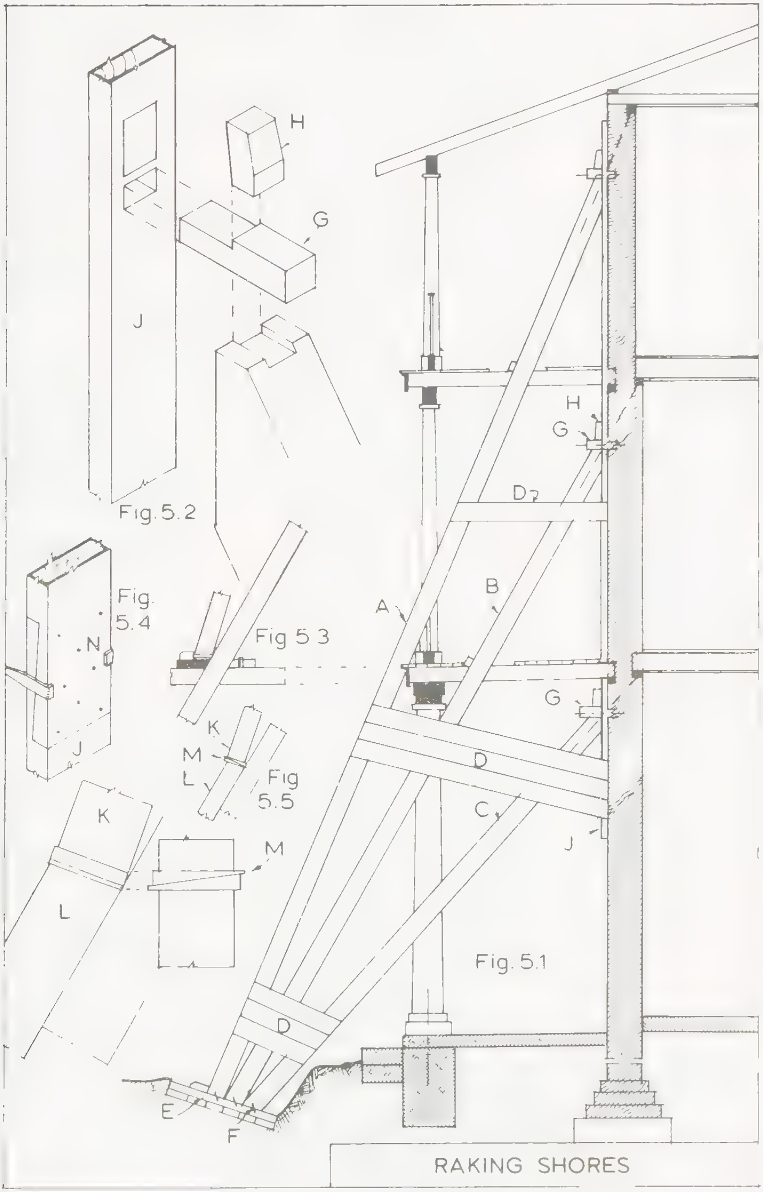
When the shoring is in position it is secured by dogs *F*, i.e., U-shaped bars with spiked ends. These need to be adjusted from time to time if left in for long periods.

DEAD SHORES. These are commonly used where new openings are to be inserted in existing buildings such as are shown by broken lines *L* in Fig. 5.6. The normal method is to insert a needle, i.e. the horizontal portion of the shore through prepared holes in the wall and to place a bed of mortar between the shore and the wall, as at *J*. This is then squeezed by tightening the wedges at *D* to give a compact seating. Figure 5.8 shows a needle *B* in position and temporary propping *F* for the floor joists. On completion of the shoring, the wall beneath is removed and a lintel of r.c. or a steel beam inserted, as shown in Fig. 5.7. New work should be protected both from hot sun and tropical rain for at least a week, after which the shoring may be removed.

Raking shores

Figs. 5.1 to 5.5 Raking shores

A	225 mm × 225 mm top raker
B	225 mm × 225 mm middle raker
C	225 mm × 225 mm bottom raker
D	225 mm × 25 mm bracing
E	225 × 75 mm sole plate on platform
F	Dogs
G	100 mm × 100 mm needle
H	100 mm × 100 mm splayed cleat
J	225 mm × 50 mm wall piece
K	225 mm × 225 mm riding shores
L	225 mm × 225 mm jack shore
M	Folding wedges
N	Wall piece splice and wall hook



RAKING SHORES

Exercise 5.1. Re-draw to any convenient scale the plan, elevation, and section of the new opening depicted in Figs. 5.6 to 5.8 to show the completed alteration after all the temporary shoring has been removed. The choice of lintel, column support, and foundation is left to your discretion.

If the wall is sufficiently stout and in good condition, it may be possible to insert new lintels without the aid of shoring. An example is given in Fig. 5.9. Here a horizontal slot or chase is cut through half the thickness of wall and a steel joist inserted. A bed of stiff cement mortar 1:2 is then placed above this joist to support the wall; when this has hardened, the other side is treated in the same way.

Sometimes strong concrete *stools* are inserted in prepared holes in the wall, as shown in Fig. 5.10. These are placed about 600 mm to 1 m apart. After bedding firmly in position, the intervening wall is cut away and reinforcement threaded horizontally through the stools as shown. Concrete is then cast around the reinforcement and into

Dead shores

Figs. 5.6 to 5.8 Dead shores
- *A* Dead shore
- *B* Needle
- *C* Sleeper
- *D* Folding wedges
- *E* Dogs
- *F* 100 mm × 100 mm floor struts
- *G* Sole piece
- *H* Head piece
- *J* Cement-mortar packing
- *K* Window strutting
- *L* Line of new openings
- *M* New lintel
- *N* New column or stanchion, if required

Fig. 5.9 New lintel without shores
- *A* Steel beam
- *B* Cement-mortar packing

Fig. 5.10 Concrete stool underpinning
- *A* Concrete stool 300 mm long
- *B* Cement-mortar packing
- *C* Reinforcement as required

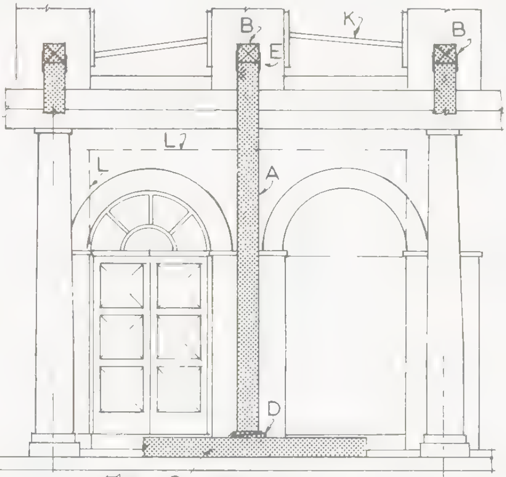


Fig 5.6

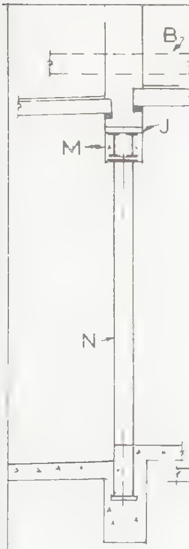


Fig 5.7

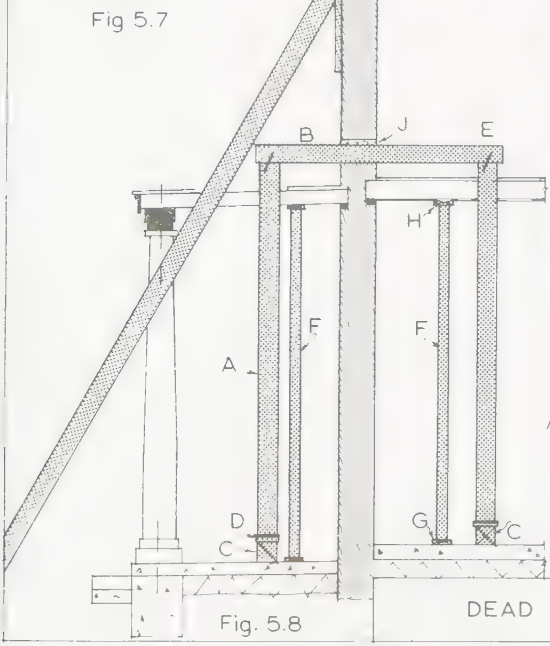


Fig. 5.8

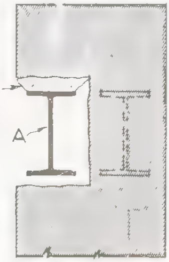


Fig. 5.9

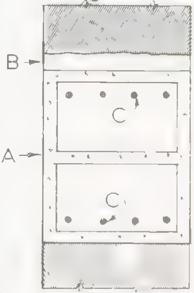


Fig 5.10

DEAD SHORES

the stools which are, of course, left in position. After the beam has set, the wall beneath is removed. This system also obviates the necessity for shoring.

HORIZONTAL OR FLYING SHORES. These are sometimes used to support parallel walls to prevent them from caving inwards, particularly where new building has to be placed between them. An example is given in Volume 3.

ARCH SHORING. The shoring of the arch shown in elevation, Fig. 5.6, is dealt with in Volume 3.

5.3 Underpinning

As the name implies, underpinning refers to the strengthening or propping of existing foundations. This becomes necessary where the foundation has settled because of poor subsoil, natural tremors, underground water, or other reasons. A usual cause in wet areas is scour of soil from rain-water. Underpinning also becomes necessary where a

Underpinning

Fig. 5.11 Concrete underpinning
- *A* Existing wall
- *B* Concrete underpinning
- *C* Formwork built up as work proceeds
- *D* Expanding steel prop (if available)
- *E* Cement-mortar packing

Fig. 5.12 Masonry block underpinning
- *B* Concrete blockwork
- *C* Dry concrete fill
- *D* Prop raised as work proceeds
- *E* Cement-mortar packing

Fig. 5.13 Order of excavation for underpinning
- *A* 1200 mm × 1200 mm sections excavated together, then *B*

Fig. 5.14 Piled underpinning
- *A* Existing foundation
- *B* New piles
- *C* R.C. beams precast or cast *in situ* (or steel beams if available)

Fig. 5.15 Earth auger for bored piles

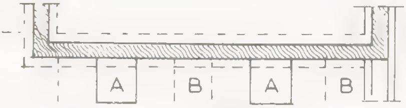


Fig. 5.13

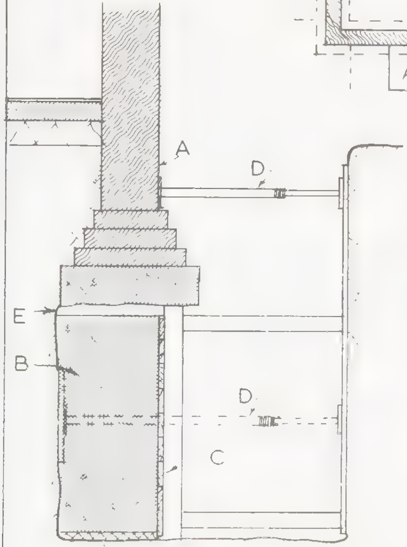


Fig. 5.11

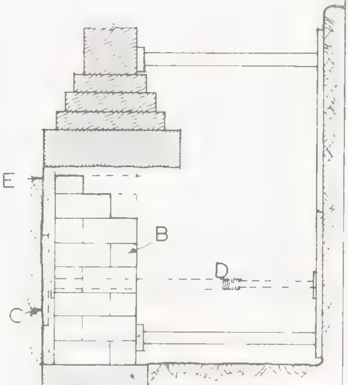


Fig. 5.12

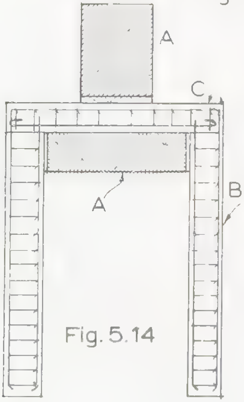


Fig. 5.14

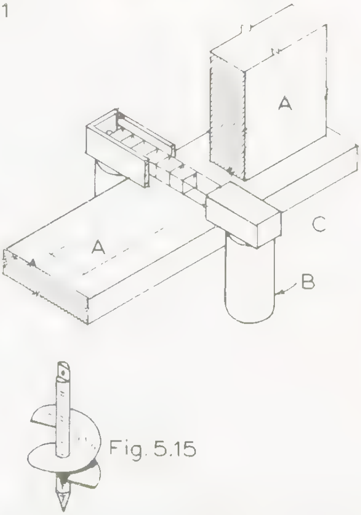


Fig. 5.15

UNDERPINNING

basement is required and new foundations are needed.

Figure 5.11 shows one method of underpinning. This is done by digging pits to the required depth, *A*, Fig. 5.13, erecting formwork *C*, Fig. 5.11, and placing fairly dry concrete in position, preferably by poker vibrator. The boards are added as the work proceeds. A space of 75 mm is left at *E* for a firm packing of cement mortar 1:2 to be rammed between the top of the new concrete and the underside of the existing foundation. The latter should be cleaned on the underside before the concreting begins. The process is repeated with pits *B*.

A second method is shown in Fig. 5.12 where solid concrete blocks are used. The space *C* is required to be filled with fairly dry concrete, 1:2:3 mix as the work proceeds. The top of the blockwork should be stepped in order to facilitate cement mortar packing under the existing foundation. Work is normally carried out from the outside of the building to avoid disturbance to the occupants. Where basements are required, however, the work is done from inside and the projecting footings cut off if necessary; otherwise they are built up square to floor level.

Where conditions permit, a simple method of underpinning is to

Scaffolding

Fig. 5.16 Bamboo (or metal tube) independent scaffold
A Standard approx. 1500 mm apart
B Ledgers
C Transoms
D Diagonal brace
E Sole plate
F Guard rail
G Scaffold boards
H Horizontal tie
J Tying-in bolt
K Board bearer

Fig. 5.17 Timber scaffold and ramp
L 10° ramp
M Foot slats
N Splice

Figs.5.18 to 5.20. Metal scaffolding
A Right angle coupler
B Right angle clevis coupler
C Reveal pin–base plate

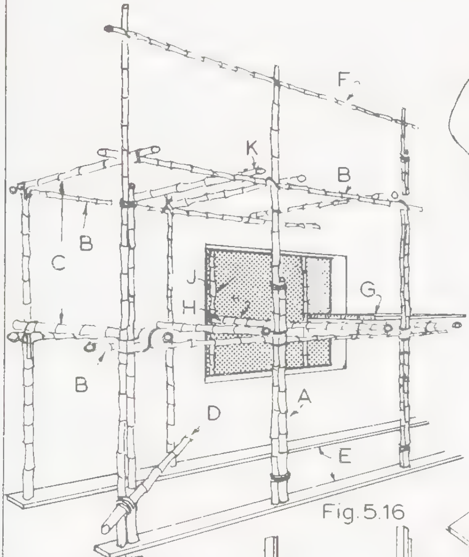


Fig. 5.16

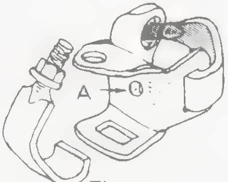


Fig 5.18A

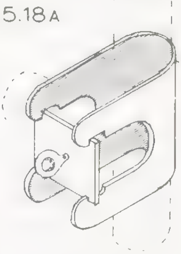


Fig 5 18B

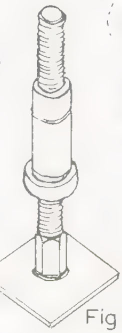


Fig 5.18C

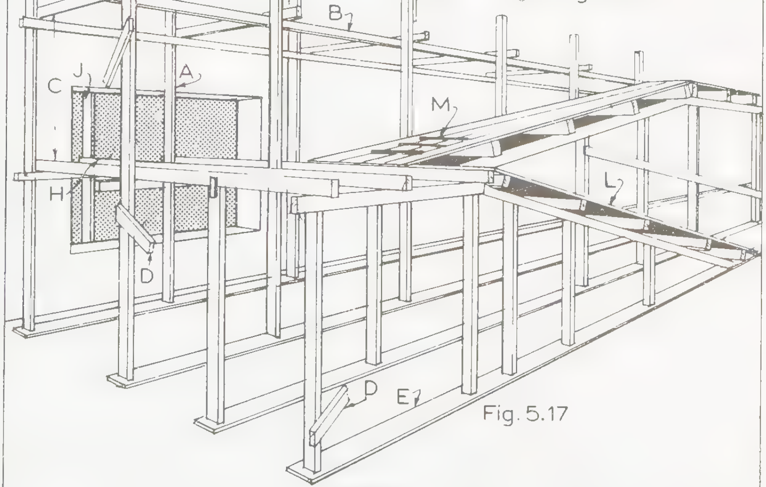


Fig. 5.17

SCAFFOLDING

sink piles on either side of the wall and insert needles of r.c. or steel beams, Fig. 5.14, as described for dead shores. One method of pile sinking, where the soil is suitable, is to bore holes with a hand auger, Fig. 5.15, and insert a cage of reinforcement, *B*, Fig. 5.14, into the hole. A useful powered auger is also shown in Fig. 6.1. The top of the reinforcement is left projecting to bond into the ground needle. If the ground is very soft, precast piles may be driven, but a careful check needs to be kept on the structure for signs of movement. This is done by inserting 'tell-tale' glasses across existing cracks and using plumb bobs to check for overturning.

Where the foundation has failed over only a small portion of the wall or at a corner the *stool method*, Fig. 5.10, is sometimes used for underpinning. The stools should be placed above the foundation strip and, if possible, below the floor level. Sufficient stools are put in to ensure that the affected area is well covered and r.c. work carried out as described.

The methods described above may not be suitable for large or heavy structures. Procedures necessary for such buildings will not be dealt with here.

5.4 Scaffolding

This is necessary for almost all building, once it has proceeded beyond man-height. It can be of either timber or metal tubes, depending on availability.

Bamboo scaffolding is still used extensively in some countries where imported material is costly and bamboo cheap. It grows in lengths of up to about 12 m or more and about 100 mm in diameter. The larger stalks are very strong, but erection can be slow because of the frequent need to tie the members together and the irregularity of the stalks. Figure 5.16 shows the general arrangement. Standards *A* are usually about 1200 mm to 1500 mm apart for masonry work. The width of the scaffold varies between 1100 and 1200 mm, sometimes only 1 m for single- or two-storey work. The scaffold is made secure by means of horizontal ties passing through windows or other openings and lashed to inside stays or posts.

Metal tube scaffolding is much more efficient and easily erected. It is also used for formwork support, exhibition stands, stadiums, seating, stairs, etc. A simple arrangement is similar to that of Fig. 5.16, but single standards at 2 m to 2·5 m centres are usual. The tubes are 50 mm in diameter and up to 6 m in length. Steel couplings vary in design according to the manufacturer and many fittings and accessories are

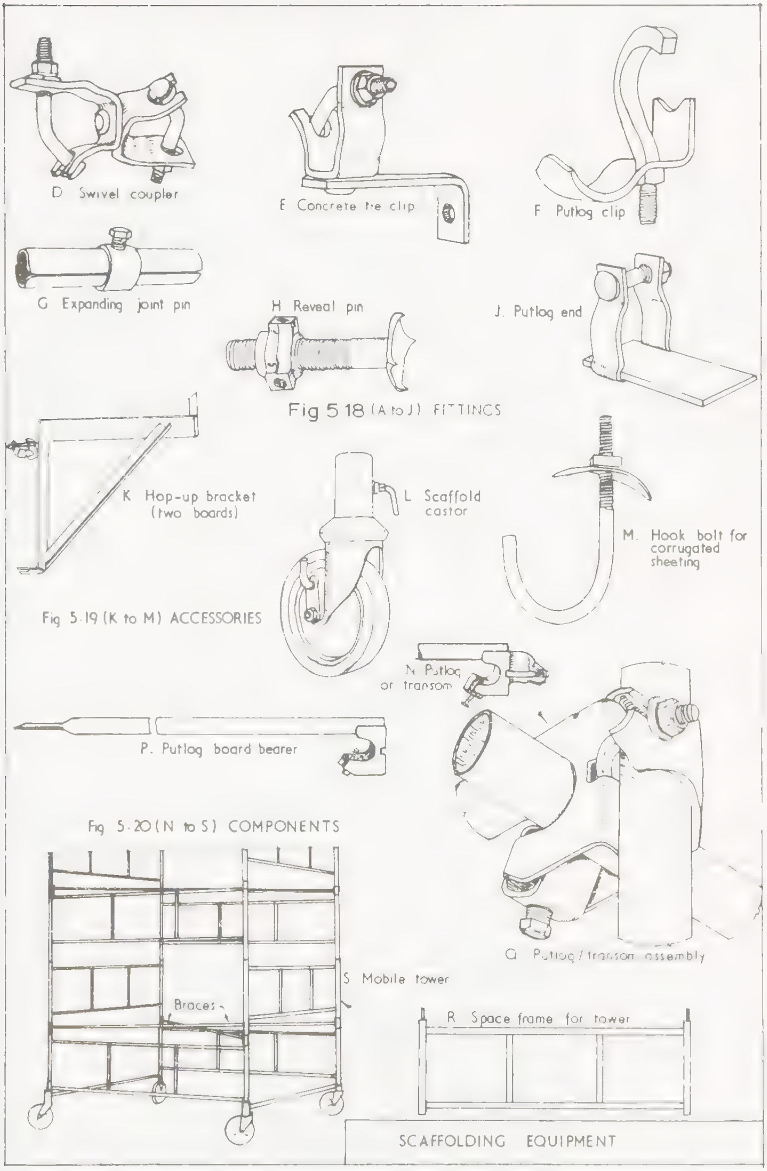


Fig 5.18 (A to J) FITTINGS

Fig 5.19 (K to M) ACCESSORIES

Fig 5.20 (N to S) COMPONENTS

SCAFFOLDING EQUIPMENT

available, Figs. 5.18 to 5.19. *Prefabricated* scaffolds of various designs, which make for speedy erection and versatility, may also be obtained. These often consist of interlocking tubes and fittings which dispense with loose couplings. One example of a mobile tower is shown in Fig. 5.20.

Timber scaffolding is used almost exclusively for medium-sized structures in the humid tropics. Sawn timber, usually about 100 × 50 mm, is used and jointing done simply by nailing. Standards are placed about 1200 to 1300 mm apart and spliced as required, Fig. 5.17. Secondary species of timber are normally used.

Ramps or walkways are normally preferred to ladders, particularly up to first floor level and also where labour is plentiful. The pitch is not more than 10° as a rule or 1 in 5. Where formwork for r.c. is being used, scaffolding is often erected at the same time and incorporated with it. This saves time and material and makes for a strong job.

The two types shown here depict independent scaffolding, i.e. the sort of scaffolding which does not depend for support on the structure itself. Brickwork or masonry walling, however, is often used

Centering

Fig. 5.21 Timber centering
A 300 mm × 25 mm shaped ribs
B Braces as required
C 150 mm × 25 mm ties
D 5-ply sheet lagging
E Bearer
F Folding wedges
G Props
H Expanding steel prop if available (otherwise timber)
J Splice

Figs.5.22 to 5.26 Steel rod centering
A 25 mm steel frame (in two halves)
B Splicing sleeve
C 100 mm × 25 mm close lagging
D Dexion or light steel angle welded to frame
E Welded diagonal bracing
F Steel cams as wedges
G Metal plate if necessary
H Sleeper

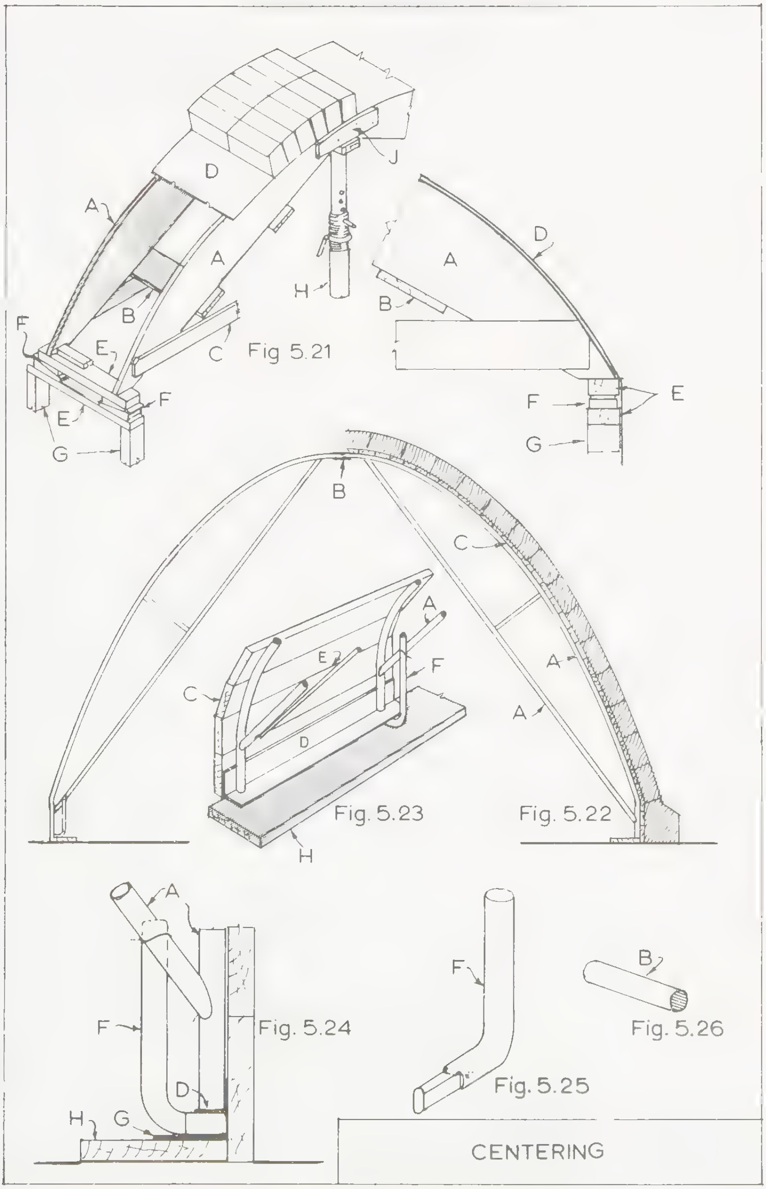


Fig 5.21

Fig. 5.23

Fig. 5.22

Fig. 5.24

Fig. 5.25

Fig. 5.26

CENTERING

to support scaffolding as it is built, in which case the inside standards can be dispensed with. The transoms or putlogs are then built into the wall and the holes filled when the scaffold is being dismantled (*P*). Special steel adaptors called putlog ends (*J*) are available for metal tubes. These are thin enough to slip into the mortar joint, which is filled when the scaffold is dismantled.

Exercise 5.2 Draw a suitable elevation of the north side of the bungalow shown in Fig. 3.23 on plan. The height and roof pitch and other details are left to your own discretion. Design a suitable scaffold in metal tube for this elevation and make a list of all tubes and accessories that you would need to erect it.

5,5 Arch centering

As mentioned in Volume 1, arches are not in general use in modern building. Occasionally, however, they are encountered and two examples of centering for light arches are shown. The first is in timber and is suitable for single arch rings of brick or stabilized earth block. In this case it has been made for erection in two halves to facilitate transport to site and for ease of erection. The halves are joined by a splice *J*, Fig. 5.21, after they have been adjusted to correct position by props *H*. Folding wedges *F* are necessary to ease the arch after it has been completed and to facilitate striking. Double ribs could be used at *A* for heavier arches, if required, and laggings of timber battens used in place of the plywood covering *D*. The centering shown, however, is quite strong enough for the single arch ring and the centre can be struck a day or two after the arch ring has been completed.

Where timber is scarce or where the centre needs to be transported frequently or used many times, the design in metal shown in Fig. 5.23 is suitable. With a parabolic shape shown, the weight of the masonry ring is largely transferred to the ground and a heavy centre is not needed. It is necessary, however, to build up both sides evenly to prevent distortion; it is also desirable to complete the arch ring in one day. Providing these precautions are taken the centre is simple and effective. The laggings are simply laid on the ribs as the work proceeds and the cam wedges lowered flat to ease the centre as soon as the ring is finished. They are pulled away, the following day usually, and the centre dismantled.

5.6 Fencing

Fencing is available in many styles and materials, including wrought iron, mild steel, and timber. It may be erected for temporary or permanent use.

A widely used type of fence is the *chain link*. This consists of 44 mm galvanized or plastic-covered chain link mesh of about No. 13 s.w.g. This can be supported by a variety of fence posts in either timber, r.c. or steel. A typical r.c. post is shown in Fig. 5.28. Where such posts can be manufactured locally they are very popular and can be made in heights and styles to suit the customer's requirements. The chain link in this case is 2 m high.

For tennis courts 44 × 5 mm m.s. angle sections are used with earth plates at 3 m centres with straining corner pillars, stays, and stiffener bars to make the whole structure rigid.

A neat type of timber fence is shown in Fig. 5.29. This consists of 150 × 100 mm to 150 × 150 mm posts with palisades nailed to both sides of the timber rails. The palisades are normally machine-sawn diagonally out of 50 × 50 mm sections. The tops may be finished in either weathered or pointed form as required. Should greater privacy be needed, the palisades could be placed closer together. Through breeze could be improved if desired by increasing the thickness of the rails.

LIVE FENCING MATERIALS. Live fencing posts can be planted in some tropical areas, as newly cut branches will take root and continue to grow. The best known species in West Africa are *Spondias lutea* and *Berlinia grandiflora*.

Hedges in most humid tropical zones grow very quickly and are planted in many varieties. For strong thorny hedges designed to discourage intruders, a good variety is *Duranta plumieri* or *Blue duranta* which is planted at intervals of about 600 mm. *Hibiscus rosa-sinensis* and *Thevetia peruviana* are also quite good. The disadvantage of all hedging material in humid zones is that it requires cutting at least twice a year, though this is less of a problem now that powered hedge-cutters are widely used.

For further information on this subject the reader is referred to *Woody Plants of Ghana* by F.R. Irvine (see Guide to further reading), and there are further examples of fencing in Volume 3.

5.7 Drives and footpaths

Approaches to buildings normally consist of drives, sometimes with adjoining footpaths. Such entrances may be simply gravel laid on a hardcore or rolled earth. Good-class building, however, frequently calls for something rather better. A fairly usual type of road and footpath in areas of high rainfall is shown in Fig. 5.31. The concrete channel can be reinforced if heavy traffic is likely to cause vibration,

Roads and fencing

Figs.5.27 and 5.28 Chain link fencing

- *A* R.C. concrete post 3 m apart
- *B* Plastic covered or galvanized link fencing
- *C* Barbed wire
- *D* Straining wire
- *E* Concrete kerb

Figs.5.29 and 5.30 Timber palisade fencing

- *A* 150 mm × 150 mm at 3 m centres
- *B* 150 mm × 75 mm rails top and bottom
- *C* Palisades ex 50 mm × 50 mm both sides
- *D* Alternative finishes to top
- *E* Concrete kerb

Fig. 5.31 Drives and footpaths

- *A* Rolled tarmacadam or bituminous finish
- *B* Pitched stones or broken hardcore, rolled
- *C* R.C. or plain concrete channel, size as required
- *D* 50 mm concrete paving slabs bedded in lime mortar
- *E* Concrete strip as slab support
- *F* Hardcore, as available
- *G* Grass verge

Fig. 5.32 Section through road kerb

- *A* 250 mm × 125 mm concrete kerb set in concrete
- *B* 50 mm concrete paving slab, as before
- *C* 75 mm tarmacadam
- *D* 150 mm pitched stones
- *E* 150 mm broken brick hardcore

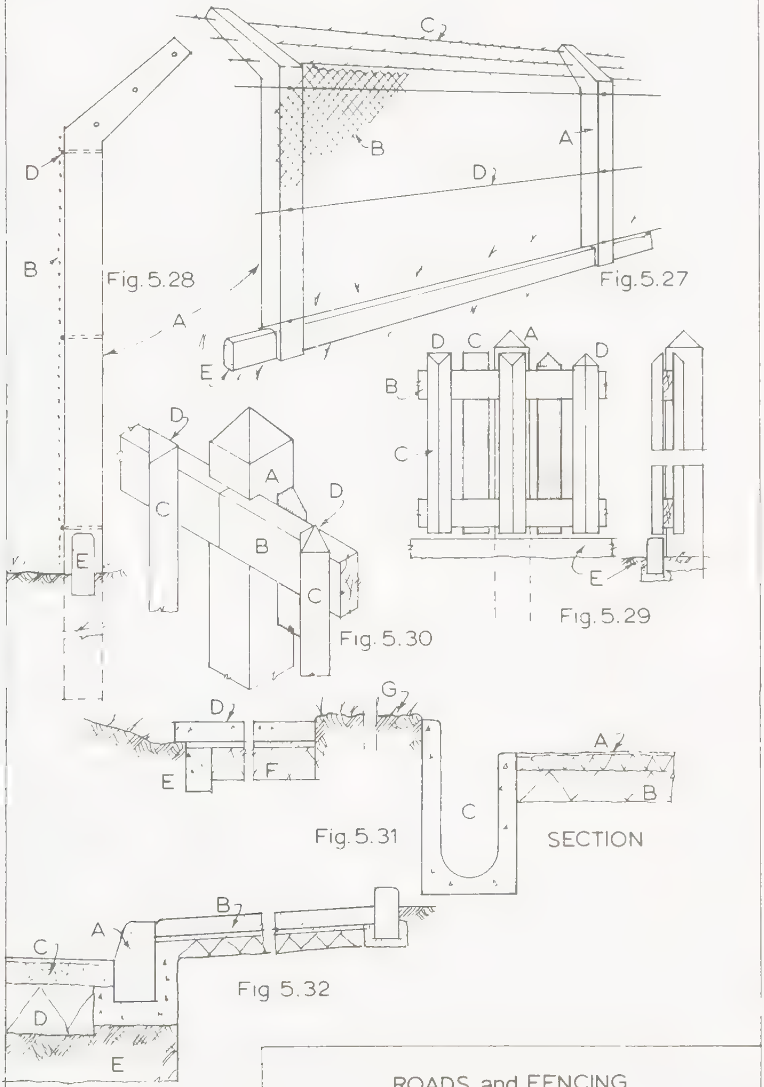


Fig. 5.27

Fig. 5.28

Fig. 5.29

Fig. 5.30

Fig. 5.31

Fig 5.32

ROADS and FENCING

otherwise it is formed simply by placing a timber core on temporary blocks in a trench and concrete in the intervening space.

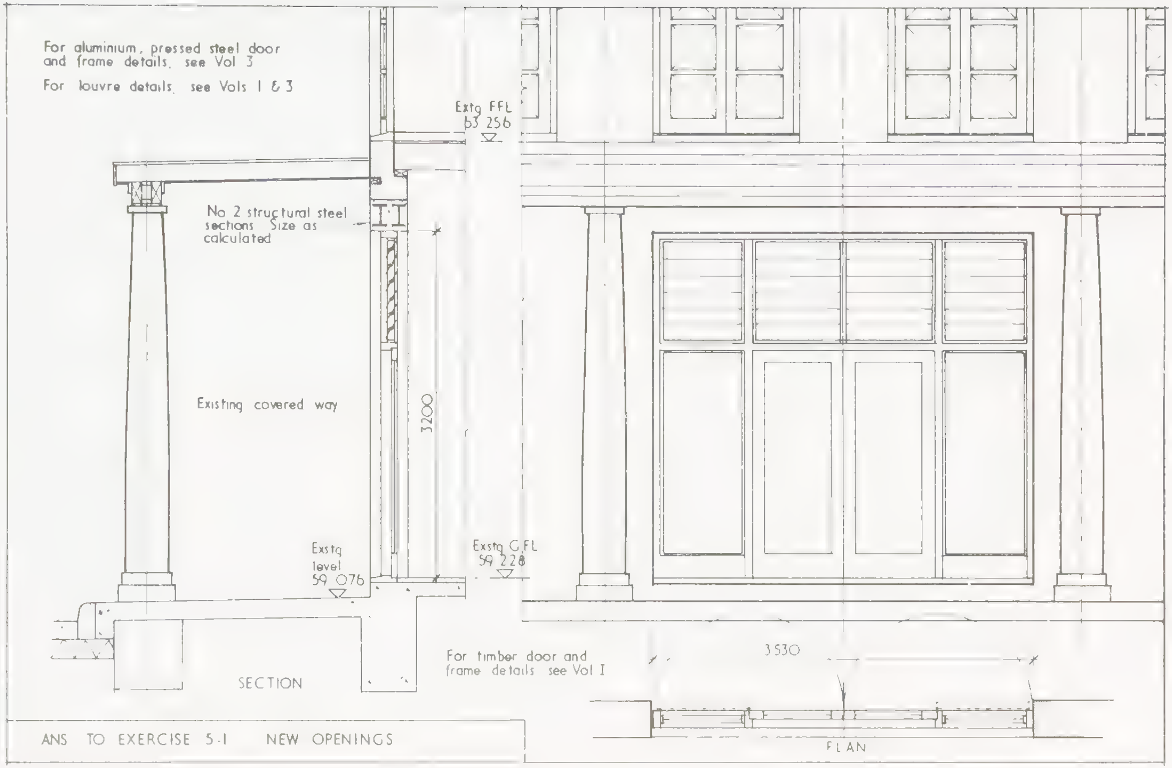
The road surface may be of 75 mm tarmacadam finished with a fine bituminous coat on a hardcore of rolled crushed brick or stone, or it may be of 100 mm to 150 mm concrete 1:2:3 mix, laid in bays of approximately 12 m × 5 m with expansion joints inserted as described for roofs. The camber or cross fall required to drain the water is normally about 1 in 48.

Footpaths of 50 mm precast concrete paving slabs are still the most popular form of paving. When laid in conjunction with a grass verge, the slab should be about 20 mm below the grass to allow for easy cutting, Fig. 5.31. The outer edge of the slab where not bedded in earth should be supported by a continuous strip of concrete.

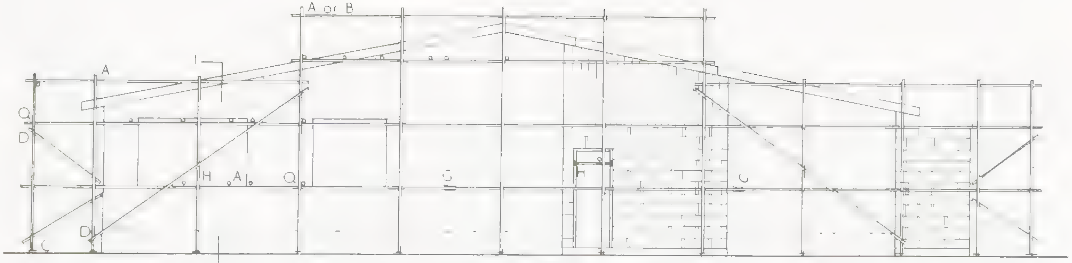
A normal type of formal approach to offices and commercial buildings is shown in Fig. 5.32. The precast kerb *A* is bedded in the concrete and is usually laid first to the correct fall, and the paved area of roadway laid to it.

Footpaths can also consist of a crazy paving of local flat stones, or of concrete granolithic paving, concrete or quarry tiles, or clay brick on edge, or just of a surface of fine bitumen.

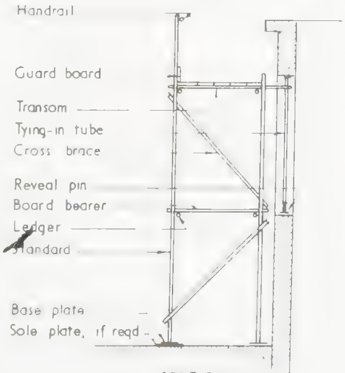
This subject has been expanded further in Volume 3.


For aluminium, pressed steel door and frame details, see Vol 3
For louvre details, see Vols 1 & 3
Extg FFL 63 256
No 2 structural steel sections Size as calculated
Existing covered way
3200
Exstg level 59 076
Exstg GFL 59 228
SECTION
For timber door and frame details see Vol I
3530
PLAN

ANS TO EXERCISE 5.1 NEW OPENINGS



NORTH ELEVATION (from Fig 3.23)



SECTION I–I

Fig. 5.18	FITTINGS	No
A	Square coupler	80
B	Clevis coupler	
C	Base plate	12
D	Swivel coupler	30
G	Expanding joint pin	12
H	Reveal pin	2
Q	Transom assembly	13

TUBES				
Length-metres	5.5	4.6	3.6	1.8
Standards	10		12	
Ledgers	12	10		
Transoms				35
Handrails		3	2	
Braces	2			
Cross braces				12
Ties etc				2

Boards, 38 mm x 225 mm x 3·6m long No 36 plus board clips

ANSWER TO EXERCISE 5·2 SCAFFOLDING

6 | Mechanical Plant

6.1 Introduction

The use of mechanical plant is not as widespread in the tropics as it is in Europe. There are a number of reasons for this; the most usual are the cost of plant, lack of maintenance facilities, and the availability of manual labour.

COST. The capital outlay involved in the purchase of power plant can be very heavy and many building firms seek to avoid this, first by hiring plant, if hire firms exist in the neighbourhood, secondly, by using a State construction organization, and thirdly, by communal purchase.

Rates charged by hire firms can be very high in relation to the price of new plant. Frequently there is no laid-down schedule of rates as is usual in Europe and often the hire firm has the monopoly for the area. There may also be inport restrictions; high rates are also usual in some developing countries where the hirer expects a quick return on his outlay.

State building organizations or local authorities are sometimes prepared to hire out plant that is not in use. This may be done at reasonable rates, provided that it can be recalled at short notice when it is needed. Such arrangements, however, are usual only in special circumstances or for the erection of government projects.

Communal buying is usual where firms are reasonably well established, and where a sound system of sharing and maintenance can be arranged. This applies normally to small organizations or to villages where self-help schemes are in operation. Often the suppliers of plant or agents arrange special terms of hire-purchase or plain hire which works out reasonably well in practice. This applies, however, only to the plant for which the agent has the monopoly.

Careful consideration has to be given to the problem of whether to hire or to buy. Apart from the capital expenditure involved in purchase, maintenance costs have to be considered. Furthermore, depreciation can prove to be considerable. Thus it pays to use plant as much as possible once it is purchased: nine months in a year should be the minimum.

Plant depot costs and other overheads also have to be met. It is usual in a well-organized establishment to have a plant depot as a self-contained unit which charges out its plant to sites at prevailing hire rates. Thus the depot is expected to show a profit. This system, although generally efficient, has certain drawbacks, it may not, for instance, have just the type of equipment the customer asks for, although it may have something akin to it. In these circumstances the contract manager may be tempted to hire from an outside source while internal plant is idle. It also means that the depot, in making an internal profit by charging current hire rates, is making the site pay more than it should.

MAINTENANCE. Site maintenance costs are those chargeable while the machine is on site in good running order. These must be added to the initial cost of the machine.

Spare parts can also raise problems. In some countries facilities for obtaining spares quickly may be poor, and much capital may have to be tied up in spares to keep machines in good order. It is thus more economical for some firms to sub-contract their repair and maintenance work to specialist firms who are often the manufacturers' agents and have the equipment and specialized knowledge for this type of work. Some agents stipulate on purchase that they should service the machines themselves and, indeed, can refuse to supply spares unless they fit them as well. This may not be a bad thing as, apart from the advantages of using fitters with specialized knowledge, these firms might not be able to function on an economic basis as suppliers without the additional profits derived from such repair work. When such conditions do apply, however, builders invariably complain of high service charges. The question of hire or purchase needs very careful consideration.

MANUAL LABOUR. In some tropical countries labour is plentiful. The rate of pay of operatives is sometimes quite low, the average daily wage often being equal to that earned in one hour in more industrialized lands. This has a big influence on the question of plant purchase. Often it is not politic to use plant purely as a labour-saving device when men are standing idle. Often, too, manual labour can be more satisfactory. It can be more versatile and is capable of reaching places inaccessible to machines. This frequently applies to some types of excavation work and concrete placing. Organized gangs are often cheaper than machines, when one considers the overheads and other charges of the latter.

Time also has to be considered economically and it is necessary not to over-estimate it. If time is not all-important the machine could lose its advantage. A progress chart is useful in helping to decide this issue (see Fig. 8.3).

Continued on page 164

There are many tasks, however, which the machine can do better than man—concrete mixing, foundation tamping, road rolling, block making, pumping, and any task where regular and systematic application is necessary for the consistent quality of the finish.

So the purchase of plant needs to be considered against the cost of hiring labour.

6.2 Factors affecting choice of plant

It is true to say that there is an economical speed of erection for most building projects and that machines help to achieve this. Economy is frequently the overriding factor and should be given priority where possible. Urgency, however, can be a prime consideration following natural or man-made disasters or in projects involving hasty resettlement of inhabitants or rebuilding. In some cases prestige projects take priority and are frequently erected whether they can be afforded or not. But in normal circumstances, cost is the main factor.

Designers of mechanical plant have to keep in mind the type of work the purchaser would normally carry out. Rarely can a single building job pay for a piece of equipment entirely, as sometimes happens with large civil engineering projects. Continuity of employment of machines thus needs to be ensured. Plant manufacturers often show great ingenuity in making their products as versatile as possible. A single piece of equipment can often do a range of jobs by means of accessories and attachments, and Fig. 6.3 shows an example. These accessories are usually quite easily fitted to the chassis. The most versatile piece of equipment in tropical building today is probably the tractor. It may be either wheeled or tracked and can be adapted to carry out a wide range of jobs.

The building itself may dictate the kind of plant best suited to its erection. It may be a long, high, steel or r.c. framed structure, or a combination of these. Where a choice of equipment exists, it usually falls on the contract manager to make the final decision.

6.3 Types of plant

These cover a wide range and it is not possible to classify them all into simple categories.

The main groups, however, fall broadly under the following headings:

1. Foundation and excavation equipment
2. Transportation equipment
3. Pneumatic, electric, and general plant
4. Concreting machinery.

Earth-moving and lifting equipment

Fig. 6.1 Earth boring machine
A Drill
B Shaft

Fig. 6.2 Dumper
A Travelling position of skip
B Unloading position

Fig. 6.3 Industrial tractor
A Front loader
B Backacter or trench hoe
C Bucket ram
D Stabilizer legs

Fig. 6.4 Angle dozer/ripper
A Seven-tine ripper beam
B Double-acting ram
C Angle dozer

Fig. 6.5 Mobile hoist
A Extendible mast
B Hoist motor
C Stabilizer legs
D Platform

Fig. 6.6 Jib tower crane
A Cantilever luffing jib
B Rotating mast
C Cabin
D Counterweight
E Rail track

Fig. 6.7 Horizontal tower crane
A Horizontal jib
B Travelling saddle
C Rotating or non-rotating mast
D Rail track
E Cabin

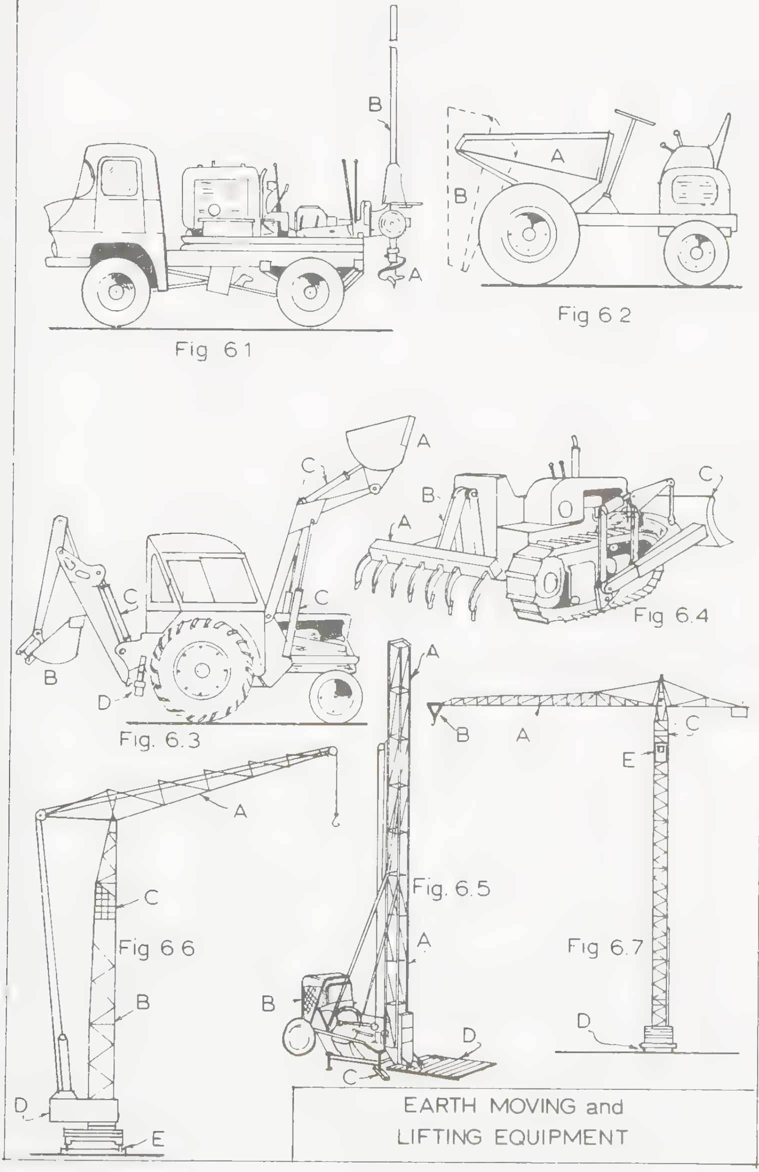


Fig 6.1

Fig 6.2

Fig. 6.3

Fig 6.4

Fig. 6.5

Fig 6.6

Fig 6.7

EARTH MOVING and
LIFTING EQUIPMENT

FOUNDATION EQUIPMENT

Heavy excavating machinery is not often seen on building sites unless the job is of some magnitude. It consists broadly of mechanical face shovels, backacters or trenchers, grabs, skimmers and draglines.

Face shovels are used in quarrying or deep excavations, embankments, cuttings, and similar work. They are operated by being driven forward and upward into the earth face. The shovel is discharged by opening the bottom over waiting trucks or dumpers.

Skimmers are similar to shovels but work by sliding or skimming evenly along the ground to give a regular finish and to reduce levels.

Backacters or trench hoes operate in the reverse way to shovels by working towards the chassis. They normally work with the bucket below ground level. *B*, Fig. 6.3 shows a small backacter attached to a tractor. Large machines have shovels or buckets of several m^3 capacity. Small machines on the other hand can be fitted with narrow hoes *B* for digging pipe or cable trenches. All the above pieces of equipment are normally interchangeable and can be mounted, if required, on a self-propelled track power unit, which usually has its own crane for converting the equipment.

Grabs or clamshells are useful for vertical working in wells or deep foundation work, for confined spaces or for stock piling. The grab is suspended from a crane and the jaws can be controlled by the crane operator. They are not much used in general building work.

Draglines are also used more in civil engineering than building. They are useful where large quantities of soil have to be moved over wide areas. They can also operate under water. The bucket is suspended from a crane, dropped to the ground, and dragged towards the chassis, filling itself as it moves along. Some buckets are of great size.

A loading shovel is a useful piece of plant for general building work, Fig. 6.3. It is normally hydraulically controlled and the bucket *A* can act as a face or loading shovel by means of a piston *C*. The bucket can also discharge into open trucks or dumpers. The trench hoe *B* can act in a similar way. The front and rear accessories are not necessarily fitted together.

Bulldozers are widely used for pushing earth to make up or reduce levels. They are made in a number of sizes and can be adapted to do many jobs, Fig. 6.4. The blade *C* can be raised or lowered by cable or hydraulic power, it may also be angled to push the soil or debris to one side of the dozer's path. A wide range of accessories can also be added.

The ripper *A* is useful for clearing roots, grass, and bushes in wooded regions and many dozers are fitted with towing bars and small cranes. Compressed air units may also be fitted to operate tools, Figs. 6.11 to 6.13. Winches are frequently added and used for towing, demolition, tree felling, etc. It can also heave itself out of trouble if it gets stuck, but, being tracked, it is very manoeuvrable in soft ground and so this is unlikely to happen. Small machines called *calfdozers* are also available for work on housing sites and medium-sized building.

Piles are often used in soft or made-up ground and these are discussed in Volumes 1 and 3. A useful machine for short bored piles is the earth auger shown in Fig. 6.1. This is also useful for drilling holes for telephone and lighting standards, cable masts, etc.; it is also excellent for boring in underpinning work as described in the last chapter. A further use is in the drilling of boreholes in site exploration and soil testing. Small borers may drill holes up to about 6 m deep and 600 mm in diameter but much larger sizes are also available. The drill may be either lorry-mounted as shown or manhandled on the ground to any required position.

PUMPS. Pumping equipment varies according to a wide range of needs. Three types only are shown here. The first and most popular is the diaphragm pump, Fig. 6.8; this model is a 76 mm to 100 mm lift-and-force pump. It can lift about 23 000 litres/h to a head of up to 6 m. As the diaphram is stout but flexible it can take muddy water, silt, or sludge without damage. A smaller version is shown in Fig. 6.9. This pump can lift water by suction up to a height of 6 m and can also force it up to a further height of 6 m, with an output of 4 500 litre/h. It can be diesel, petrol, electric motor, or hand operated.

A 50 mm electric submersible pump is also shown in Fig. 6.16. This will operate when completely under water and is light and portable.

SELF-POWERED TOOLS. These are popular with builders, especially where electricity or air supply is not available, or where cables and air tubes prove impracticable. One such machine is the rammer, Fig. 6.15, and is used where foundation soil needs to be firmly compacted. It is usually transported on a trolley and it will tamp earth firmly in places not accessible to mechanical rollers.

Other types of self-powered tools are concrete picks, drills, chain saws, chisels, etc. Some light equipment may also be operated by compact petrol engines small enough to be carried on the back of the operator. Spray guns and suction hoses are typical examples, though power for these is sometimes supplied by hand pump.

TRANSPORTATION EQUIPMENT

This is concerned with both horizontal and vertical movement of material; the latter is usually carried out by the use of hoists and cranes.

DUMPERS. For carrying loose materials, soil, concrete, small tools, and plant, etc., over rough ground, the dumper is invaluable; one of the most popular models is that shown in Fig. 6.2. It is balanced so that the load may be tipped out easily as shown at *B*. The usual capacity for dumpers is generally from $\frac{1}{4}$ m^3 to $\frac{3}{4}$ m^3, although larger ones are made. The dumper shown is designed to take the whole batch of 200 litres from a standard concrete mixer. Steering is effected through the rear wheels and the driver looks over the load. Larger versions of up to about 2 tonnes are usual on building sites.

Mechanical plant. Power tools

Fig. 6.8 Lift and force diaphragm pump
  A 75 mm to 100 mm lift, double diaphragm
  B Petrol or diesel engine

Fig. 6.9 38 mm lift and force diaphragm pump
  A Petrol engine

Fig. 6.10 Portable rotary air compressor

Fig. 6.11 Power hammer

Fig. 6.12 Air pick

Fig. 6.13 Electric drill

Fig. 6.14 Cartridge or stud hammer

Fig. 6.15 Self-powered rammer

Fig. 6.16 Submersible pump (electric or air)

Fig. 6.17 Power hand-saw

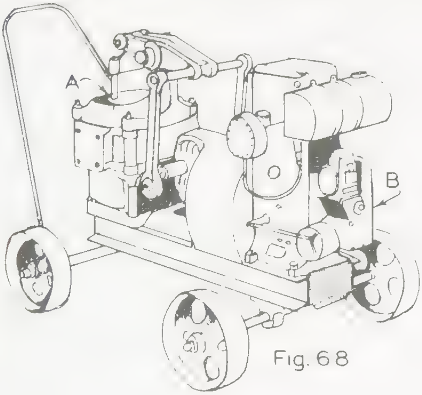


Fig. 6.8

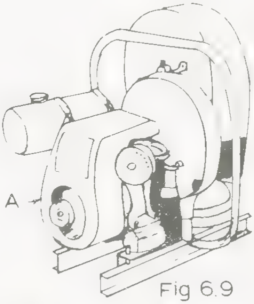


Fig 6.9

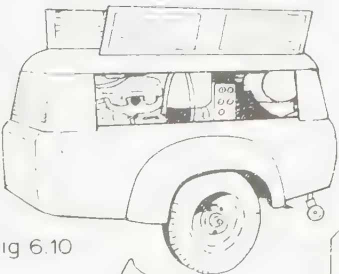


Fig 6.10

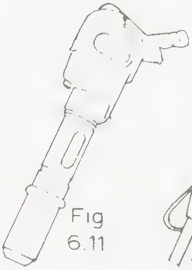


Fig 6.11

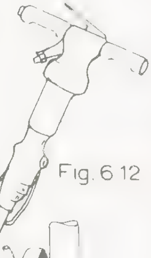


Fig. 6.12

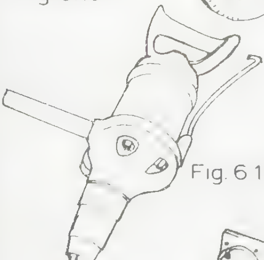


Fig. 6.13

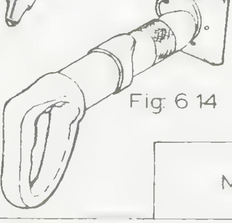


Fig. 6.14

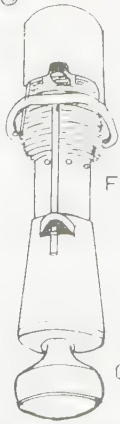


Fig. 6.15

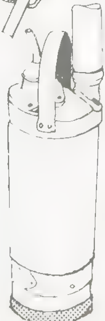


Fig. 6.16

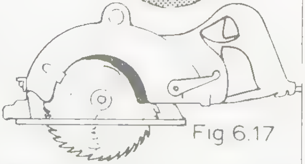


Fig 6.17

MECHANICAL PLANT. POWER TOOLS

TRACTORS. A widely used piece of equipment for all general purposes is the rubber tyred agricultural tractor. It will perform most of the tasks of its tracked counterpart and in addition is faster and more mobile, particularly on public roads. It is extensively used for towing trailers, 6.24. When the latter is fitted with a hydraulic ram *B*, it becomes a tipper, which greatly increases its scope. The hydraulic power is supplied by the tractor.

The tractor-trailer is an excellent short haul vehicle and will carry most of the things a job needs. When not being used as a tipper, the trailer may be quickly detached and left behind for loading or unloading. As tractor-trailers are also in wide agricultural use it means that supplies, servicing, maintenance, etc., are usually more efficient and economical.

Figure 6.23 shows a tractor in use for soil-stabilizing roads and Fig. 6.25 shows it in use as an efficient, if inelegant, light road-roller. This helps to make the roller an economical piece of equipment More efficient vibratory hand rollers are on the market, but their cost is higher and they can deteriorate if not used for long periods.

Trucks are normally used for long hauls and general soil disposal; the short wheelbase 5 tonne tipper is widely used, but for general duties and light transport it is normal to employ a pick-up truck, which is indispensable to the general contractor of today.

CRANES AND HOISTS. For vertical transport of building materials there are two main categories, namely, cranes and hoists. Cranes are not yet in general use for medium-sized building, particularly if of r.c., the hoist being preferred. During recent years, however, there has been an increase in the number of tower cranes in use, especially in large towns.

Two general types of tower crane are shown in Figs. 6.6 and 6.7 The first is a *rotating mast* crane with a cantilever jib. It is easily erected and capable of handling all material on a normal building site. On level sites it can be mounted on rails, which increases its range considerably.

Figure 6.7 shows a typical tower crane with a *horizontal jib*. The saddle *B* travels horizontally along the jib. When the cranes are mounted on rails they can often reach any part of the site. They are made up to 30 m in height unsupported and can swing through an arc of 360°. They can effectively resist winds of hurricane force at this height.

The advantage of a horizontal jib with a travelling saddle is that the load can be brought closer to the mast than with the *derricking* type, although the latter can be raised to clear obstructions. Both types are normally self-erecting, i.e. use their own power (electric) and mast for erection purposes. Many tower cranes are now made with non-rotating masts. These are sometimes telescopic and can be erected to any height, provided they are anchored back to the building as construction proceeds.

Hoists are in more general use than cranes, although they are not as versatile and capable only of vertical movement. They are cheaper than cranes and can be easily erected as the work proceeds. They can also be dismantled quickly and re-erected elsewhere. The platform normally takes two barrows, though larger ones are available. The shortcomings of hoists can usually be overcome by the addition of manual labour hence their popularity.

Many tropical buildings are long and narrow and often only two or three storeys in height. For these the mobile hoist is very useful, Fig. 6.9. It is manoeuvrable and can be erected by a few men in a very short time. The mast is usually up to 10 m long.

Road or lorry-mounted cranes are sometimes seen on sites but are not in normal use except for handling special equipment such as air-conditioning plant, lift motors, etc. They can usually be hired for such special purposes.

6.4 Compressed air and general plant

A wide range of tools and equipment is now operated by compressed air, and most contractors have compressors. A few types of air-driven tools are shown in Figs. 6.11 to 6.13. Air is supplied by *portable compressors*, Fig. 6.10, which are obtainable in several sizes. Concrete-breakers, spades, picks, shovels, hammers, rotary drills, chisels, rammers, vibrators, and pumps are some of the tools on which compressed air can be used. The tools are quickly interchangeable. Probably the tool most widely used with compressed air is the pick. Compressed air spades are normally used for heavy clay soil which is difficult to dig by hand. The type of compressor illustrated could take a number of air hoses, depending on its size. Small compressors are also available for single hand-tools such as *poker vibrators* or *drills*. This type of compressor may also be fitted to a tractor. Small portable cylinders of compressed air are also popular for inflating tractor or lorry tyres, cleaning out formwork, or removing waffle moulds to r.c. floors, etc.

Portable hand-tools may also be driven by electricity, and, where the supply of current is suitable, electric small tools are in general use. A full range of woodworking tools is available as well as saws, drills, grinders, and polishers for use by other trades. A drill, Fig. 6.13, and a circular saw, Fig. 6.17, are shown here.

Other electric machines in use in the tropics are the *floor sander*, for wood strip and block floors in timbered areas, and the *carborundum* *grinding* machine for terrazzo work. The latter, however, often has its own petrol engine. The cartridge or stud gun in Fig. 6.14 has already been discussed.

Powered hand-tools, particularly electric ones, need regular cleaning and inspection and the user should be instructed as to their maintenance. Makers' instruction books should be carefully followed, and if the operator is unable to understand these they should be explained to him.

6.5 Welding plant

No list of tropical building plant would be complete without welding equipment, particularly as most plant needs to be imported and periodic repairs and improvisations often become necessary.

Concrete and block plant

Fig. 6.18 Non-tilt drum concrete mixer
A Non-tilt drum
B Petrol or diesel engine
C Loading hopper
D Batch weighing dial
E Drag feeder mechanism
F Water tank

Fig. 6.19 Small mobile mixer
A Tilting drum
B Tilt hand lever
C Feed chute
D Hauling pole

Fig. 6.20 Drag shovel
A Skip
B Drag line
C Control button

Fig. 6.21 Concrete block machine
A Tamper plate
B Finished block
C Pallet
D Box
E Pushing out lever

Fig. 6.22 Rotary hydraulic pressure block machine

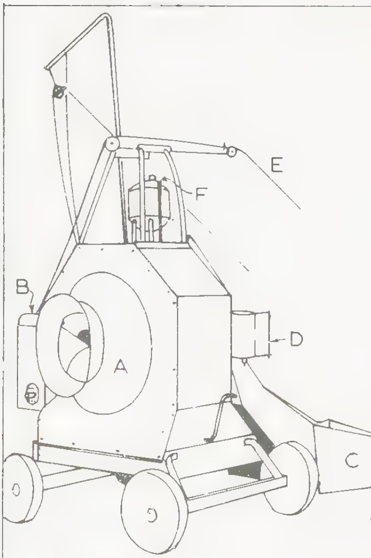


Fig. 6.18

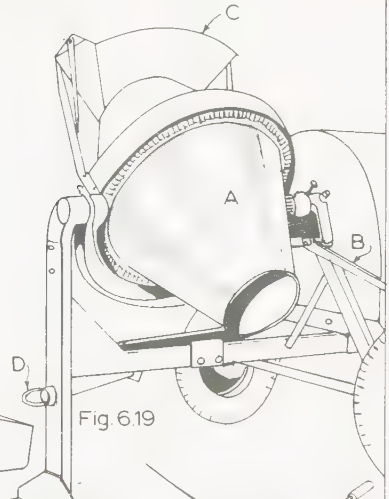


Fig. 6.19

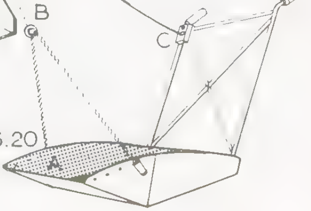


Fig. 6.20

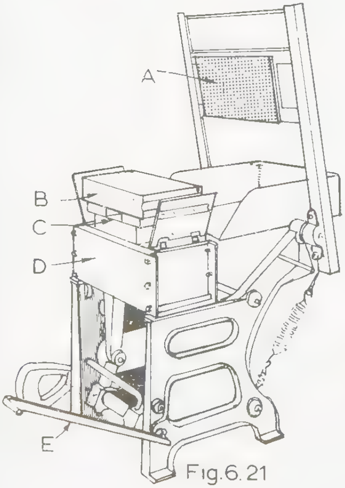


Fig. 6.21

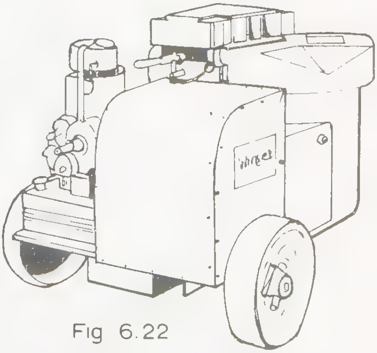


Fig 6.22

CONCRETE and BLOCK PLANT

Welding consists of fusing together metal surfaces at high temperatures; it can be carried out by two methods, namely, oxy-acetylene and electric arc. The oxygen and acetylene are transported in separate bottles or cylinders of steel and the mixture of the gases is regulated by the operator using a gun or blowpipe. Strips of metal called *filler rods* are used to deposit fused metal along the joint to make it at least as strong as the surrounding material.

The *electric method* uses a metallic arc in which the filler rod is itself an electrode. It is replaced as it is used up. Usually the current is supplied by a petrol or diesel-driven generator which provides the high current and low voltage needed for this type of welding. Such generators will supply only one or two blowpipes, which is adequate for normal purposes. Larger output could be obtained from a motor generator.

6.6 Concrete-making equipment

Concrete mixing has been referred to in Volume 1. The type of machine used by average contractors is the tilting drum shown in Fig. 6.19. It is made in a number of sizes from 85 to 400 litres for normal use. The one illustrated is a 100 litre T (tilting) mixer and is very mobile; it can be towed by a truck or tractor, at fast speeds if necessary. It is easily manhandled and has a chute at the rear for easy filling. Most tilting drum mixers, however, are hand-fed from the front.

A large mixer is shown in Fig. 6.18 and is normally referred to as a non-tilting type (N/T). This is a hopper-fed model with a self-raising

Tractor attachments

Fig. 6.23 Soil stabilization equipment
A 55-80 b.h.p. tractor
B Three-point linkage
C Rotor speed gearbox
D Pulverization gear

Fig. 6.24 Hydraulic trailer
A 3 m × 2 m all-steel tipper
B Hydraulic tipping gear
C Hand brake
D Draw bar

Fig. 6.25 Tractor road roller
A Roller
B Chain drive from tractor
C Sprocket and chain steering
D Steering wheel

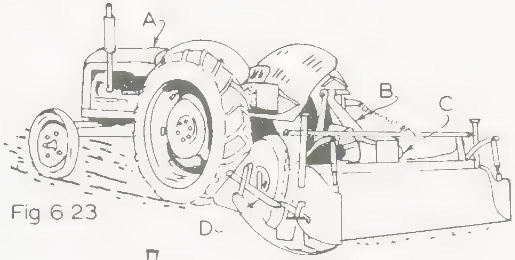


Fig 6 23

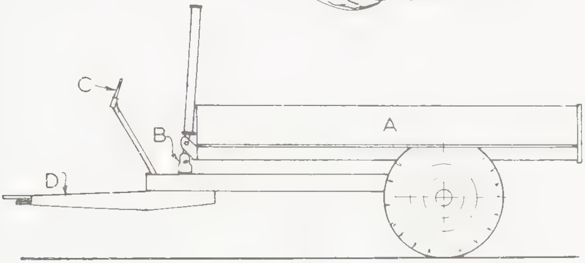


Fig 6 24

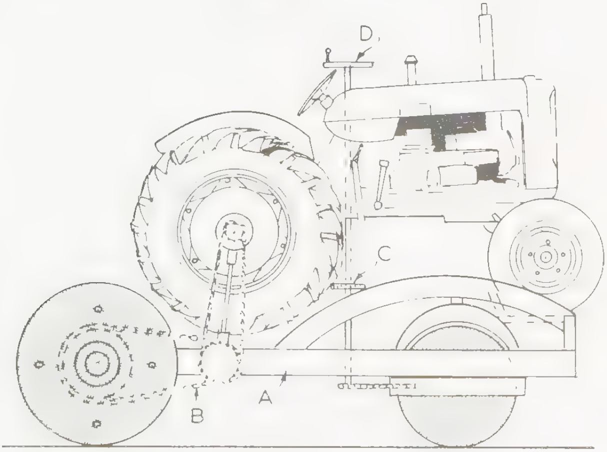


Fig 6 25

TRACTOR ATTACHMENTS

skip *C* and a built-in weigh-batcher *D*. Drag-feeder attachments *E* may be supplied as an extra. These enable the drag shovel (like a wheelbarrow without the wheel, Fig. 6.20) to be dragged over the stockpile to fill the hopper or skip. This equipment, however, is not widely used where labour is plentiful.

6.7 Block-making machines

There are numerous models of these on the market which are capable of turning out a great variety of blocks. Figure 6.21 shows a typical hand-operated machine. This is a combination slab-, block-, and brick-making machine, all of which can be produced by inserting the appropriate accessories. Blocks can be made 460 × 230 mm in area and from 50 mm to 225 mm deep. Slabs and blocks may be made tongued and grooved as shown, or with plain ends if required. Hollow blocks, hammer or rock-face finish, frogged bricks, etc., can all be produced by the use of additional equipment. Electric vibrating machines are also made to produce denser blocks, while others will make gate and fence posts, pillars, lintels, and roofing tiles.

Figure 6.22 shows a rotary hydraulic block machine for the production of stabilized soil blocks for low-cost building. Cement/sand blocks can, of course, also be made. It can be operated without special skill and can produce blocks at a rate of up to 180 per hour. A popular size is 300 × 300 × 150 mm, particularly on self-help projects.

7 | Soil and Soil Stabilization

7.1 Introduction

Natural soil without additives is in widespread use as a building material throughout the tropics, and its history dates back from the earliest times. In dry climates, such as Luxor in Egypt, the remains of earth structures and arched vaulting centuries old can still be seen today. The earliest reference, however, possibly dates back to Pliny who in A.D. 67 recorded the existence of soil-built watch-towers built by Hannibal, the famous Carthaginian general, almost 300 years before.

There are many buildings which have been erected in many different climatic environments throughout the world, which are constructed entirely of soil, and some of them are quite famous. Kano, a town in Northern Nigeria, is one striking testimony of this. Apart from these, early settlers including missionaries put up soil-built schools, churches, and community centres, some of which are still in use today. Despite this, natural soil in most developing countries is considered a lowly material whose use is confined to low-cost building, largely in villages.

With the aid of additives, chiefly Portland cement and bitumen, the use of soil is becoming much more widespread. The production of good block-making machines is also helping to popularize its use, although it may yet be some time before the local inhabitants will be prepared to abandon their traditional ways of building.

7.2 Methods of natural soil building

Cob. This is extensively used in tropical Africa, where suitable earth is obtainable over wide areas. The best mix consists of soil, gravel, sand, clay, and fine stones in roughly equal proportions, sometimes with chopped straw or grass added. Laterite makes an excellent material for cob walling. Where there is a preponderance of clay, sand is sometimes added to reduce cracking, though this is unusual.

Mixing is simple. The topsoil is removed and the subsoil dug up with a hoe, a sturdy hand tool which serves also as a pick and a shovel. Water is added to the loose soil which is then kneaded by treading and chopped grass added if required.

The wet cob is rolled into balls or lumps about 200 mm in diameter which are then bedded on the wall to form courses about 600 mm high; the outside of the wall is then scraped smooth. With the usual corrugated-iron roof and veranda supported by wooden posts, these walls will last for years. Failure, when it occurs, is usually a result of scour or faulty foundations.

Pisé de terre consists of ramming slightly damp, almost dry, soil between stout formwork with heavy rammers. This makes a sturdy wall when made thick enough with properly prepared soil. It is not now widely used, adobe blocks being preferred.

ADOBE OR SUN-DRIED BLOCKS. These are simply blocks made from soil mixed as cob, usually without straw. The prepared soil is thrown in bottomless wooden moulds normally about 300 × 200 × 125 mm. The blocks are usually cast in pairs and the mould removed as soon as the block is made, it is stiff enough to retain its shape and is left undisturbed until firm enough to handle. The block is turned up after a day or two to assist in drying. No pallet is used.

WATTLE AND DAUB. This method of building small village houses is extensively used where bamboo or suitable stalks are available. It consists of a framework of split bamboo or stalks held by studs of thin poles or branches. The latter are sometimes forked at the top to support the roof. The soil, prepared as cob, is daubed on either side of the laths, which act as reinforcement. Sometimes double skins of laths are built about 150 mm apart and the cob thrown between them, the outside then being rendered with mud.

The above methods of building are age-old and used extensively. Construction is simple and crude; no supervision is needed, and the grading of soil practically unknown. Collapse sometimes occurs, often as a result of poor roofs and foundations, but it rarely causes severe hardship, as new walls are quickly built and the roof timbers transferred.

The addition of cement or bitumen to soil, however, is now affecting local custom, especially where block-making machines are available to communities, and it is with these materials that we shall now deal.

SOIL STABILIZATION. The main weakness of the foregoing methods lies in their low resistance to water. Such walls are often said to need 'a good hat and boots' to survive. Overhanging eaves and verandas help considerably but tropical rain of any intensity can damage unprotected walls.

Soil when mixed with cement, lime, and/or bitumen has greatly-increased strength and weatherproofing properties, particularly when properly graded under supervision. The addition of the correct amount of water for mixing is also important; with care, walls of excellent durability can be built. Soil-cement walling is also used in areas where suitable sand is not available or where transport costs are high. However, sand-cement blocks are frequently made with inferior sand or under piece-work conditions and do not compare in strength with a reasonably well-made soil-cement block.

Soil-cement walls may be built in several ways. They may be rammed between climbing shutters as with *pisé de terre* or constructed of blocks made by hand or with either of the machines shown in Figs. 6.21 and 6.22.

A fairly simple way of building walls is to erect grooved concrete posts similar to those described for fences (see Volume 3). Stout formwork panels then span the uprights on either side and are held in position by bolts which, when tightened, cause the panel to grip the posts, which are normally about 180 mm square. The forms are usually about 600 mm high and the mix made semi-dry for ramming. Soil-cement blocks, however, are more widely used and we shall now deal with these.

TESTING SOILS. Before work of a reasonable quality can be carried out with stabilized soil, it is necessary to know something of the soil constituents and how to determine these by field methods. It is not every type of soil that is suitable for the purpose. For example, soil containing too much clay, say, over 25 per cent, can be difficult to stabilize, and unclean soil containing organic matter will not make good walling. There are a number of laboratory tests which can be used to determine soil constituents and properties, but generally only field tests will be dealt with here.

These tests usually consist of:

visual examination;
touch examination;
sedimentation tests leading to silt and clay tests.

Visual examination can be a very good guide to the nature of soils. The appearance can give an indication of the amount and fineness of the sand present, and from this a general idea of the silt and clay proportions may be gained.

Touch testing. The feel of the soil is also indicative of its suitability for building. Generally sand is distinctively rough, whereas the texture of dry silt is similar to that of very fine sand. Dry clay is sometimes felt as coarse grains which resist pulverization. Wet silt is plastic, almost clayey, to the touch. Wet clay is very plastic and sticks easily to the fingers.

Sedimentation test. To find the approximate proportions of coarse sand, fine sand, and combined silt and clay in the local soil, a simple field test may be carried out. To do this a glass or plastic jar or bottle of about a half litre capacity is used. The soil, without stones, is added to the jar until it is about a quarter full. Water is then poured in until the jar is about three-quarters full. The jar is then covered with a lid and shaken vigorously, then left to settle. After one hour it is shaken again, then left undisturbed for 8 hours. The water above the soil sample is ignored.

The soil sample should now show distinct stratification with the layers of sand and combined silt and clay clearly visible. Sometimes the sand itself separates into coarse-and fine-grained strata but not always. The depths of the layers may now be measured and the sample, to be satisfactory, should show the sand and the combined silt and clay to be present in roughly equal proportions. Field tests usually give lower results than laboratory tests due to some silt and clay being trapped in the soil and also to the fact that some material remains suspended in the water above the soil.

Silt and clay identification. Soils containing large amounts of clay and silt show marked changes when their moisture content is varied, and this property is not favourable to building soils. Silts and clays are identical in appearance when pulverized and dry, but can easily be identified by their behaviour in water. Silts are fine grains which are rapidly affected by water and when dry are easily pulverized with the fingers. Clays, on the other hand, are plastic in a moist state but difficult to pulverize when dry. Changes in moisture can, however, cause pronounced shrinkage or expansion and they are difficult to compact when moist. It is necessary, then, to determine whether silt or clay predominates in the soil sample; this is done by using the *shaking and squeezing test.*

Shaking and squeezing test. To perform this test a sample of soil is prepared and left for an hour to become saturated as for the sedimentation test. The jar is then shaken vigorously and the mixture left to settle for 30 seconds. The surplus liquid is then siphoned off by means of a rubber hose or tube into a flat shallow dish. This is again allowed to settle and the clear water carefully poured away. The residue is then allowed to dry, after which it is ready for testing.

Enough of this residue is taken to make a ball of about 20 mm in diameter, it is made plastic by adding water as necessary. The ball is placed in the palm of the left hand which is then struck vigorously with the right. This has the effect of shaking the ball which tends to bring a film of water to the surface. Should the water film appear and disappear quickly during and after shaking, it indicates a lack of plasticity owing to the presence of fine sand or silt. No change in appearance, on the other hand, suggests considerable plasticity indicating the presence of clay in some quantity.

The ball in next squeezed with the fingers. Should the water disappear and the ball tend to crumble, then silt or sand may be assumed to be predominant. If the ball simply deforms into a dripping mass, it denotes clay of considerable plasticity.

Dry strength test. This is performed by allowing the ball to dry in the sun and then squeezing it hard between the finger and thumb. Plastic clay cannot be pulverized in this way whereas silty material will disintegrate easily. Several tests should be made to ensure reliability.

The tests so described, though by no means conclusive, give a fairly good indication of the content of the soil. A good soil suitable for stabilizing should be compactable when dry and not shrink appreciably. It should consist of a mixture of sand, silt, and clay with adequate cohesive properties. Soils containing more than 25 per cent of clay have a tendency to shrink and generally, soil containing one half sand and the remainder rather more silt than clay is satisfactory.

SOIL-CEMENT BLOCKS. The addition of cement to the type of soil just described will, in normal circumstances, produce a block which is fairly stable and will not shrink or expand owing to the presence of moisture; nor will it deteriorate when subjected to driving rain or continued dampness. If well made in either of the block-making machines shown in Figs. 6.21 or 6.22 it will produce a block with a compressive strength sufficient for all normal purposes.

Preparation of soil. Except in very dry areas, the soil used for building is normally too wet to be mixed straight after digging. The best plan is to dig at the end of the wet season, if possible, when it is easier to work, then spread it in shallow layers to dry. It can then be sieved ready for mixing with cement.

The soil can be tested for moisture by taking a handful and squeezing it. No water should appear on the surface and the soil should disintegrate when the hand is opened.

For good-quality work the soil should be sieved through a 5 mm wire mesh sieve, and any material over this size should be rejected. The wire screen, usually about one metre square, is rocked in a horizontal position by one man holding handles at one end, the other being suspended by ropes from above.

Cement. The quantity of cement needed will depend on the quality of the work, its location, the age and quality of the cement, the type of soil used, and the method of mixing.

Test blocks made up of different quantities of cement are usually examined after about two weeks. This is done by placing the block between two supports and breaking it by suspending weights from its centre. The breaking loads are then compared. The blocks can also be struck with a hammer and if they are hard enough they should produce a metallic ring. A 100 mm nail when dug into a block can also give a reasonable indication of hardness. Soaking the block for 7 hours in water also gives a measure of its resistance to disintegration.

As a rough guide, sandy soil needs, say, 5 to 10 per cent cement, silty soil from 10 to $12\frac{1}{2}$ per cent, and clayey soil from $12\frac{1}{2}$ to 15 per cent cement. The latter, however, is not recommended.

Mixing. Hand- or machine-mixing of soil-cement is carried out as for concrete. This has been described in Volume 1.

Water is often added indiscriminately, without regard to the workability of the material or its subsequent strength. A simple field test to check water content is to take a handful of the mixture after wetting and squeeze it. It should then retain its shape without soiling the hand; it should also be capable of being pulled apart without disintegrating; but a ball of material dropped from a height of one metre should disintegrate into loose material again.

Blocks. These should be stored on a dry, level surface protected from rain and sun and allowed to dry slowly during the first day. After this they should be sprayed regularly for 8 days. Blocks should not be stacked or piled until they are 3 days old. If possible, blocks under 21 days old should not be used. The mortar used for laying blocks should be of the same mix as the soil cement. It should not contain more cement than the block itself.

FOUNDATIONS. Soil-cement foundations are set out as described in Volume 1. The trench, however, should be well drained, and a layer of small stones placed and well compacted in the trench bottom. Soil-cement is then added in 100 mm layers and well rammed to ground level. Alternatively, soil-cement blocks themselves may be used, in which case they should contain not less than 10 per cent cement by volume. The bottom of the trench should be well rammed and a 100 mm layer of concrete 1:3:6 first laid on which blocks may be built.

In areas subject to earth tremors, or where there is likelihood of uneven settlement, this layer is always advisable and can, if necessary, be reinforced with m.s. rod. The exact amount of steel is difficult to determine, but 12 mm rods at 150 mm centres laid longitudinally should suffice with 10 mm distribution bars at 200 mm centres tied crosswise to them.

BITUMEN BLOCKS. Although soil-cement blocks are widely used, bitumen-stabilized blocks are also usual in low-cost housing, outhouses, or farm buildings. The average amount of bitumen stabilizer is about 5 per cent by weight of the dry earth sometimes with 15 per cent kerosene added to the bitumen to make it more workable.

Coal tar may also be mixed with earth and is sometimes used for building blocks, although bituminous emulsion is more common. To make a block of reasonable quality, the soil should first be treated as for soil-cement.

Hand mixing is normal but slow. Bituminous emulsion, unlike cement, mixes readily with wet earth. It is advisable, however, to take only a quarter of the batch of soil and mix the whole amount of bitumen and water with that. Dry earth is then added to give a homogeneous mix. The moisture content of bituminous stabilized blocks is normally about 20 per cent.

Block laying is done in mortar of the same mix as the earth but with the large aggregate removed. Cement mortar with bitumen stabilizer may also be used.

RENDERINGS. Although not strictly bituminous stabilization, a good waterproof finish may be obtained by making sun-dried adobe blocks by hand or machine and applying a single coat of bitumen rendering as described in Volume 1. Such blocks provide an excellent key and it is, of course, the cheapest method of all.

SOIL-CEMENT ROAD AND PAVINGS. During the past thirty years the use of soil-cement as a surfacing material has increased greatly, and it is now extensively used for small airfields, playgrounds, car parks, etc. It is widely used in the tropics but more as a civil engineering than a building material. For drives, foot paths, entrance roads and paved areas, however, it is invaluable.

Good soil-cement paving consists of pulverized soil and cement with the correct moisture content, thoroughly compacted preferably by machine. Its success depends on the grading of soil, correct proportions of cement and water, and good workmanship. The first of these should be determined in a laboratory, but building work on a small scale may be carried out by applying the field tests already described.

Sieving. Granular soils for pavings generally should have a particle size distribution approximating to the following:

Maximum size	75 mm
Passing 45 mm	over 50%
Passing 500 μm	over 15%
Passing 75 μm	below 50%
Finer than 2 μm	below 30%

Details of test sieves and methods for test sieving may be found in B.S. 410 and 1796 respectively. Figure 7.1 shows a typical graph for recording soil grading tests on laterite suitable for block making, but not suitable for pavings.

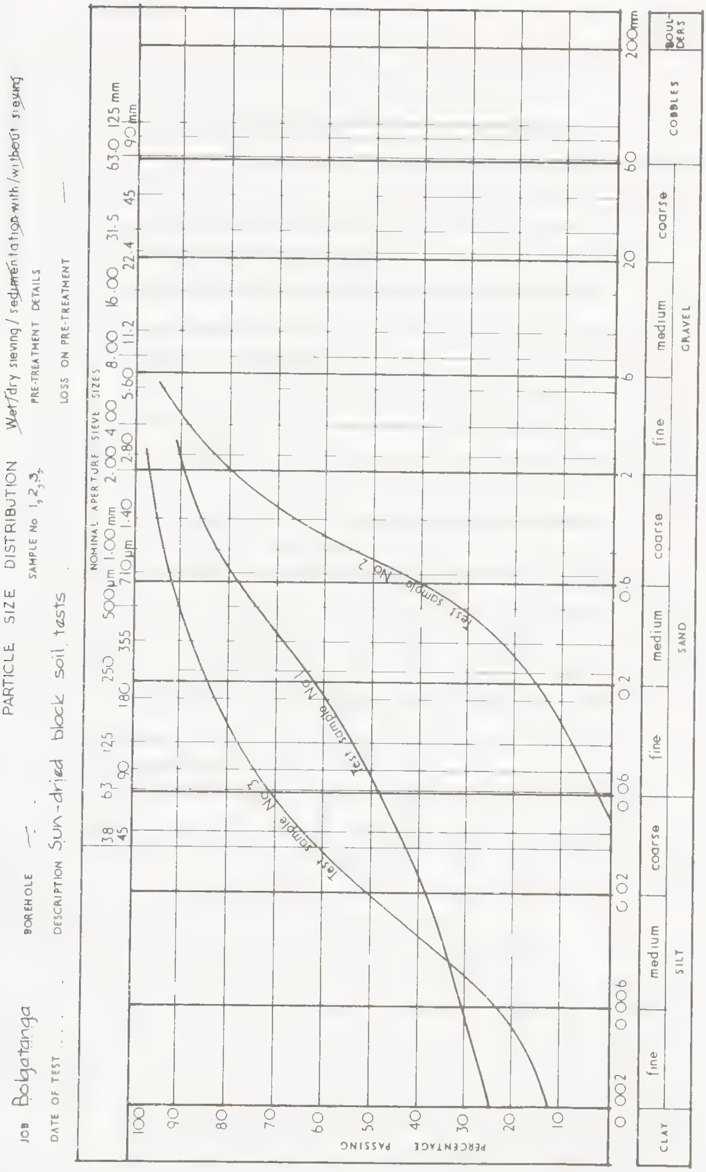
Moisture content is very important. It should be checked when mixing and pulverizing takes place and again when compaction of the soil-cement occurs. For mixing and pulverization the soil should be approximately at its *plastic limit*, i.e. the moisture content point at which soil can be rolled into threads of 3 mm diameter, whereupon the thread breaks. With granular soils this is not so important.

For moisture content in compaction, trial sections should be prepared with different moisture contents, the one selected having a content just below that at which the mix begins to push under the roller. An idea of this can be obtained from the plastic limit test described above.

The cement content can be determined fairly accurately for extensive work by means of soil samples subjected to compressive strength tests For general purposes, however, the minimum cement content may be taken as 7 per cent.

Site preparation. First the site has to be stripped of topsoil and then cambered and shaped to its formation level. A straight crossfall is usually easier for drainage purposes than a camber and this is often done.

The processes after site preparation are pulverization, adjustment of moisture content, cement spreading, mixing, adding water, grading, compacting, and curing. The initial breaking up of the soil may be done if necessary by tines, as shown in Fig. 6.4, though a tractor/plough can also do the job. Towed rotary tillers specially designed for the work are also available. Pulverization depth is usually 200 mm to give a finished soil-cement base of 150 mm. After pulverization the surface is graded again to crossfall or camber and lightly rolled. Water is added to correct moisture content by means of a travelling tank and spray. The cement is spread by simply laying out bags at predetermined intervals. It is mixed by a rotary hoe, Fig. 6.23, until the mixture is of uniform colour.



PARTICLE SIZE DISTRIBUTION

JOB Bolgatanga

DATE OF TEST . . . .

BOREHOLE -

DESCRIPTION Sun-dried block soil tests

SAMPLE No 1, 2, 3

~~Wet~~/dry sieving / ~~sedimentation with~~/without ~~sieving~~

PRE-TREATMENT DETAILS

LOSS ON PRE-TREATMENT —

FIG. 7.1 SOIL GRADING TEST

The machine shown will prepare a road width of 2 metres to a depth of 200 mm. It permits an accurate moisture control and will pulverize and mix to an even base in one or two passes. Large works normally have a train of machines which enable all the foregoing operations to be carried out in a single pass.

The final rolling of hard standings, playgrounds, and small work can be done by a tractor roller as shown in Fig. 6.25. Vibrating hand- or towed-rollers are excellent, if available, for light rolling and for compacting edges.

8 | Project Management

8.1 Introduction

A building organization of any size needs to be administered efficiently to be economically sound. It is not enough for each department to know its own duties and have the means of carrying them out; it must be integrated into the structure as a whole in such a way that co-operation between all sections is possible and effective.

There are many aspects of administration; those which are concerned with overall policy; those which exist solely to provide a service, e.g. publicity, training, personnel, and so on; and those which are executive in function, and which are directly concerned with production. It is within this last category that the duties of the contract manager lie.

Building organizations vary greatly in size, scope, and function. No two are alike, and it is possible here only to generalize on the duties of a project or contract manager. Before attempting to do this, however, it is necessary to dwell briefly on the work of those departments which are fairly common to most enterprises in order that a clearer picture of the manager's duties may be obtained. It is not proposed to mention again the departments discussed in Volume 1.

Every building organization, whether public or private, could, if its management were so minded, draw up a network showing the relationship of one department to another. Each department could, in fact, by putting itself in the centre, illustrate its own lines of communication by graphical means. Such a diagram has been drawn up in Fig. 8.1, with the duties of the contract manager at the hub.

The function of the surveying, estimating, plant, planning, accounts, estate, legal, buying, and office administration have already been touched upon. Some organizations produce a comprehensive folder for their staff, which, being in loose-leaf form, may be amended as required. This can be a useful document if periodically brought up to date. Other important departments for the contract manager are:

DRAWING OFFICE. This can be either architect- or civil engineering-based, or both. In large organizations it may be divided into separate departments, particularly where it is state controlled and large enough to give a complete service in both sections. The contract manager usually makes more use of the engineering section, once the project is under way, because it is here that r.c. detailing, bar-bending schedules, structural steelwork, timber structures, formwork, piling, gantries, and similar temporary work are designed. Some offices also carry out their own consultancy work.

RESEARCH. Most modern construction companies and concerns of any size have a research department. This is concerned with giving advice on the properties and use of materials, and investigating the causes and symptoms of defects. It can also advise on complicated design assumptions, or unorthodox methods of construction. It sometimes carries out site investigations, tests new materials, and is often responsible for the design and testing of reinforced, precast, or prestressed concrete. Routine testing of concrete cubes and advice on improvement in design of concrete mixes come within this category.

Research can also embrace the duties of the soil mechanics department. This deals with foundation problems, bearing pressures, made-up ground, quality-control of earth fill, dewatering, temporary roads, drilling, soil testing, etc. Frequently it works closely with government research institutes on testing materials and equipment.

TRAINING. More attention is being paid to practical training of junior technical staff than hitherto. Progressive organizations now usually have comprehensive training schemes whereby suitably qualified young men circulate through departments and sites which will ultimately concern them. Some are later attached to contract managers or executives as personal assistants. An important task of the project manager or other executive is to train his own successor. Owing to the dearth of suitable trainees this is not always possible, but the aim should always be born in mind if the organization is to prosper.

8.2 Duties of a project manager

Figure 8.1 shows the range of contacts necessary to the project manager, and with this in mind it is now proposed to describe his more usual functions.

PRE-CONTRACT PERIOD. Collaboration with the estimator at this stage is essential. Where tenders are invited or competed for, the project manager is usually required to produce a method statement on contract procedure as this may affect the contract figure.

Having won the contract, he then needs to examine the drawings

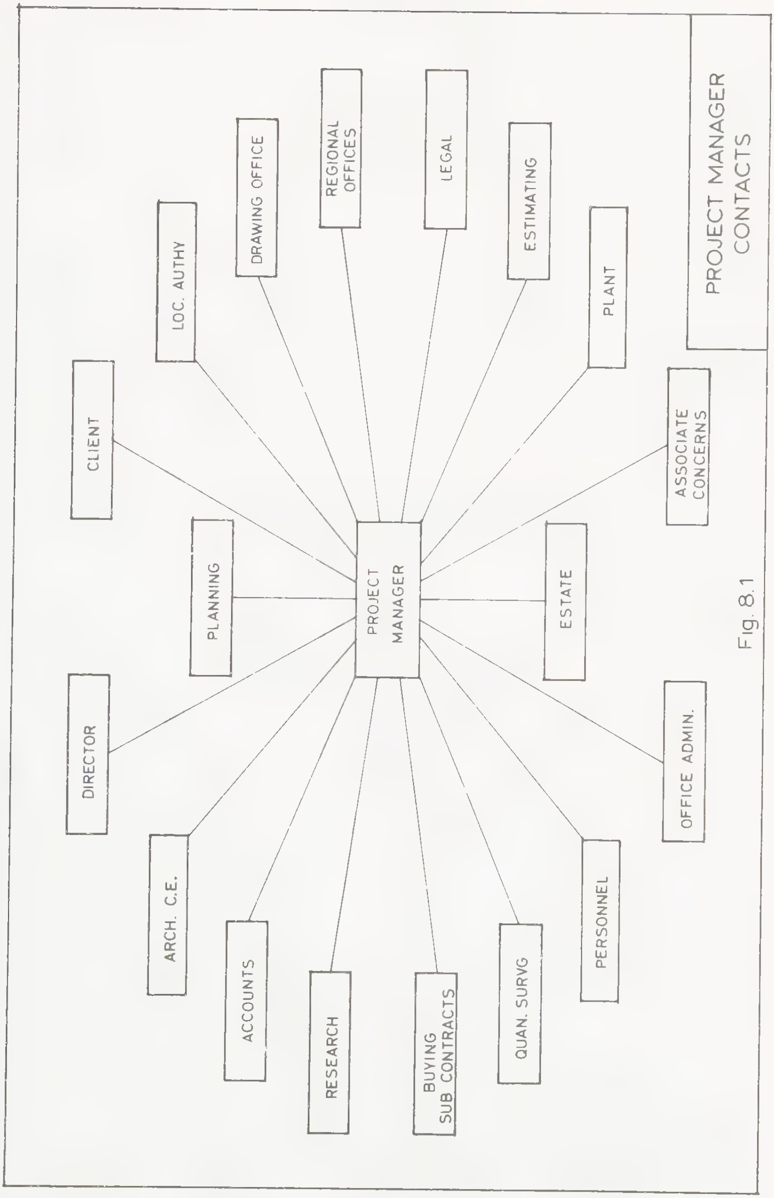

PROJECT MANAGER CONTACTS
PROJECT MANAGER
CLIENT
LOC. AUTHY
DRAWING OFFICE
REGIONAL OFFICES
LEGAL
ESTIMATING
PLANT
ASSOCIATE CONCERNS
ESTATE
OFFICE ADMIN.
PERSONNEL
QUAN. SURVG
BUYING SUB CONTRACTS
RESEARCH
ACCOUNTS
ARCH. C.E.
DIRECTOR
PLANNING

Fig. 8.1

and documents for errors and omissions, at the same time he will study the requirements of the job and draw up a plan of action. This will involve consideration of the methods of construction and the sequence of operations. The latter is best done by means of charts and networks, specimens of which are shown in Figs. 8.3 and 8.4. He will then check that the starting date is, in fact, a realistic one judged against the organization's facilities and current commitments.

His next task will be to advise all concerned of the new job. This is usually done by means of a statement similar to that shown in Fig. 8.2. This is circulated to the departments shown in Fig. 8.1 and is sufficient to satisfy immediate needs. He then notifies the public authorities and seeks the necessary permissions and permits to build. This cover gantries, hoardings, rights of way, water supply, and similar items.

He now needs to decide on the quantity and type of staff, labour, material, and plant he will want for the job.

STAFFING. This is normally done by first preparing a schedule of personnel requirements showing the dates when such staff would be needed. This is then submitted to the appropriate department, namely, personnel, if such exists, for necessary action. Following this, he may be required to assist in interviewing new staff, if wanted, or otherwise seeing those members of staff who could be transferred from other departments to work for him. A knowledge of interviewing techniques can be invaluable in helping him to get the information he wants. Perhaps the most important member of his staff would be the site agent.

MATERIALS. The project manager will, by now, have received from the estimator and/or buying department a list of materials and components needed for the job. He will work closely with the Buying Department investigating alternative sources of supply and probable delivery dates. From this he will prepare, with the estimator, a complete schedule of materials showing the type and quantity of each item and the date it will be needed on the job. He must also ensure that the buying department has a copy. Loose materials and those in continuous demand, cement, sand, etc., are normally ordered in bulk and delivered as required.

When new forms of materials are to be used, e.g. plastics or synthetics, he may need to inform the research department that tests for strength, weathering, heat resistance, and suitability will be necessary.

The cost of labour and materials is an important consideration. Some contracts contain *fluctuation clauses* which enable the contractor to claim against inflation affecting prices and wages. The quantity surveyor normally supplies the project manager with a list of basic rates for labour and materials which has been agreed between the contractor and the building owner.

Proper records must be kept both on site and in the Q.S. office so that monthly claims can be made and included in interim payments. The architect or consulting engineer is usually informed of this separately by the surveyor.

PLANT. The plant department will need to be advised of probable plant requirements together with a programme showing dates when it will be needed. A separate schedule of plant not owned by the organization should also be prepared for action by the plant department which will then decide whether to hire, buy, or adapt. The projects manager will also need to ensure that the site agent has plans for proper maintenance and repair of equipment and instructions to return it to the depot at the earliest possible date.

Portable tools and hand plant also need consideration with the services of the electrical, plumbing and similar departments. These duties, however, are usually left to the site agent.

SUB-CONTRACTORS AND SUPPLIERS. These are often under the surveillance of the Q.S. and the estimating department. The project manager, however, is ultimately responsible for the cost of his contracts. He likes to ensure that alternative quotations are received from different sources, in order to see whether price advantage or improved performance is possible. He also scrutinizes arrangements made by the architect or C.E. (consulting engineer) with nominated suppliers and sub-contractors to ensure that they are reputable firms and that conditions of contract and delivery dates can be observed.

Where a sub-contractor or supplier is new to the organization, he should be requested to give sight of his fidelity bond or similar guarantee of financial standing. This is important in areas where an organization has otherwise no redress against default. He should at the same time check that insurance policies cover all sub-contractor's work and equipment and that these are adequate.

The next step is to prepare a schedule of P.C. (prime cost) and P.S. (provisional sum) items showing details of service, B.Q. (Bill of Quantity) reference number, and starting and delivery dates. The schedule should also contain provision for intermittent supplies, where this applies, and actual, as against estimated, delivery dates. Delay in delivery times should be noted. Premature delivery of supplies also has to be guarded against, if possible, as it could lead to deterioration as well as taking up storage space. The B.Q. then needs to be checked against the drawings to see that they tally. Further copies of the relevant drawings with amendments, if any, may then have to be sent to the sub-contractors. They will, of course, already have had an initial set on which they based their tender.

SITE AGENT. The duties of the site agent or controller have already been dealt with in Volume 1. The project manager will need to check that all preliminary work has been carried out, that signboards, traffic guidance signs, etc., have been posted and that all is ready to start. The amount of site responsibility delegated to the site agent will depend on his experience, and some overlapping will be inevitable. The project manager should, however, arrange short-term plans with his site agent and ensure that these conform to the programme.

CONTRACT DRAWINGS. The project manager will need to obtain all the drawings necessary to start the job on time and see that the drawings are supplied when needed. He should also notify the architect or C.E. of any discrepancy between drawings and the B.Q. He must also arrange distribution of drawings to all who need them.

VARIATIONS AND CLAIMS. Building contracts are rarely carried through precisely in accordance with the original plans; it is usual for architect's instructions on variations to be received from time to time. It is normally the task of the site agent to assess the effect of these variations on the job as a whole and to ascertain whether progress has been affected. He must confirm all verbal orders in writing and obtain variation orders for them. He also refers to the contract manager all instructions received from sources other than the architect or C.E.

The project manager of necessity frequently has direct contact with the building owner and often acts as liaison between client and architect. Should such contact result in a variation, care must be taken to ensure that this is recorded and payment obtained through the Q.S. if necessary.

Any causes of delay likely to give rise to extension of time must be officially recorded and a claim put in, if necessary. The negotiation of claims is usually done by the Q.S.

RECORDS AND PROGRESS. A complete record, accompanied by photographs where applicable, should be kept of each job and all items of significance or interest entered in it. Much information for this record is obtained from the site diary.

OLD TOWN BUILDING CO. LTD.
COXTON ROAD
BANGMWA

CONTRACT DETAILS

Date: 26th August, 19 . . . .

Project No.	42/30
Name by which Contract will be known	Hall of Residence Contract No. 1
Address	University, Bangmwa
Name of Client	University of Bangmwa
Nature of Contract	Erection to Ground level
Form of Contract	Standard with Quantities
Value of Contract	Q40,083
Starting Date	29th September, 19 . . . .
Contract Period	16 weeks
Method of Payment	Certificate
Percentage of Retention Money	10%
Limit of Retention	10%
Surveyor: Architect:	Odunlami & Spencer Fasehun & Ajula
Special Conditions	—
Project Manager	G. Afieri

Distribution:

Directors; Branch Managers; Agents; Labour Office; Chief Cashier; Chief Buyer; Plant Man.

Fig. 8.2.

PROGRAMME AND PROGRESS CHARTS. These are usually required to be drawn up under the instructions of the architect or C.E. and a clause to this effect is usually inserted in the specification. Some authorities require that a *programme and progress chart* be drawn up in accordance with the standard practice of the appropriate Ministry. In the words of one publication:

'Programming means setting down in logical sequence all the things that will have to be done and estimating the time, labour, and materials that will be needed for doing each of them . . . It provides the architect, contractor, and supervisory staffs with a clear plan of operations.'

Progressing not only records what has been done but also compares actual progress with the programme. A simple chart shown in Fig. 8.3 illustrates the procedure. In order to cut down the chart to manageable proportions, some items such as steel reinforcement have been omitted.

Before the contract manager can proceed with the preparation of such a chart, he needs certain information from his estimator. This includes a *material schedule* containing approximate quantities of materials, a breakdown of labour costs giving constants, and also a priced B.Q. The estimated completion date for the contract is usually given to him.

Having determined the amount of work to be done in terms of measurable units, e.g. m^3 and man-hours per unit, the total man-hours for each operation can then be calculated. The number of days or weeks required for each operation is based on experience and the nature of the job, but can be varied according to the number of men employed. This figure is given at the bottom of the chart.

The bars are hatched when the chart is prepared and filled in solid as the work proceeds. The normal method of recording progress is to divide the bar into an equal number of parts, each bar representing a portion of the work, say, 100 m^3 or 1000 blocks, etc. A movable 'time now' indicator, usually of coloured string held vertical and taut by drawing pins, is moved at, say, weekly intervals as the work measured is recorded on the chart. Should the inked-in bar fall behind the indicator, progress is behind schedule (Item 8). The actual quantity of work done may be written above the bar as it is inked in to give a permanent record of progress. One such quantity has been recorded.

A refinement to the chart may be added by inserting a horizontal time-line below the bar while an operation is proceeding. This line always ends at the indicator until the operation is completed. At the indicator the same figure is recorded as on the bar (3000, item 8). When progress is up to schedule, the bar figure and the time-line figure which are identical are above each other, if not, the horizontal distance between the two shows the time over-run or under-run. In this case blockwork progress is 3 days behind schedule. Progress figures for other bars and weeks have been omitted for clarity.

Apart from its use in recording progress, the estimator finds such a record useful for checking his unit estimates against actual performance, which assists him in the preparation of future tenders.

Such charts as have just been described have been in use in Europe for many years. Although they serve a useful purpose, they are somewhat inflexible and cannot be quickly adapted to unforeseen delays or alterations to the project. Their main drawback, however, is that they fail to indicate at a glance the implication or significance of an operation over-running its allotted time or failing to start on schedule. The system described below helps to overcome these drawbacks.

8.3 Critical path method

This system, rather newer than the traditional bar diagram, is simple and flexible and can be quickly adjusted to changing requirements as the project proceeds.

A simple C.P.M. network has been drawn up in Fig. 8.4 which illustrates the procedure. It has been developed for the same job as described for the bar diagram so that a direct comparison may be made. To assist the reader, the item numbers in circles on the progress chart have been made to coincide with the events on the C.P.M. network. Under this method, it is first necessary to divide the whole job up into tasks or activities, each activity in the network being represented as a link between numbered events, usually shown in circles. These are points in time marking the beginning and end of each activity.

A whole operation, e.g. events (1) to (4), may be broken up into two or more activities. The most difficult part of the system is working out the sequence of events. It must be remembered that no new activity can be started until the one preceding it has been completed.

With this in mind the reader should now turn to Fig. 8.4. At event (1) two activities proceed independently of each other, i.e. site layout (sheds, etc.) and site clearance (trees, shrubs, etc.). After 7 days of site layout, shown in brackets, event (2) occurs when 'temporary services' may be started. Site layout then proceeds to completion (Day 16). After 3 days of temporary services, however, event (3) occurs (Day 10), which marks the start of erection of temporary offices, etc.

Setting out cannot start until the site is cleared, layout completed, and temporary services installed. The estimated time for site clearance is 14 days. But site layout will take 16 days, so site clearance time is

Continued on page 196

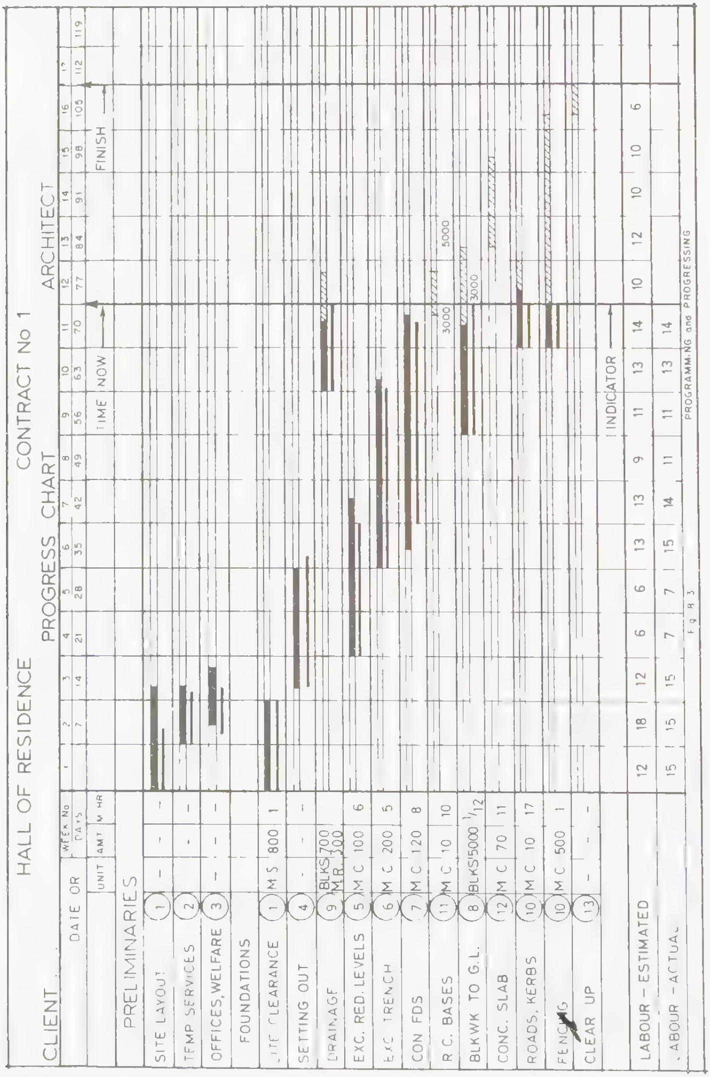
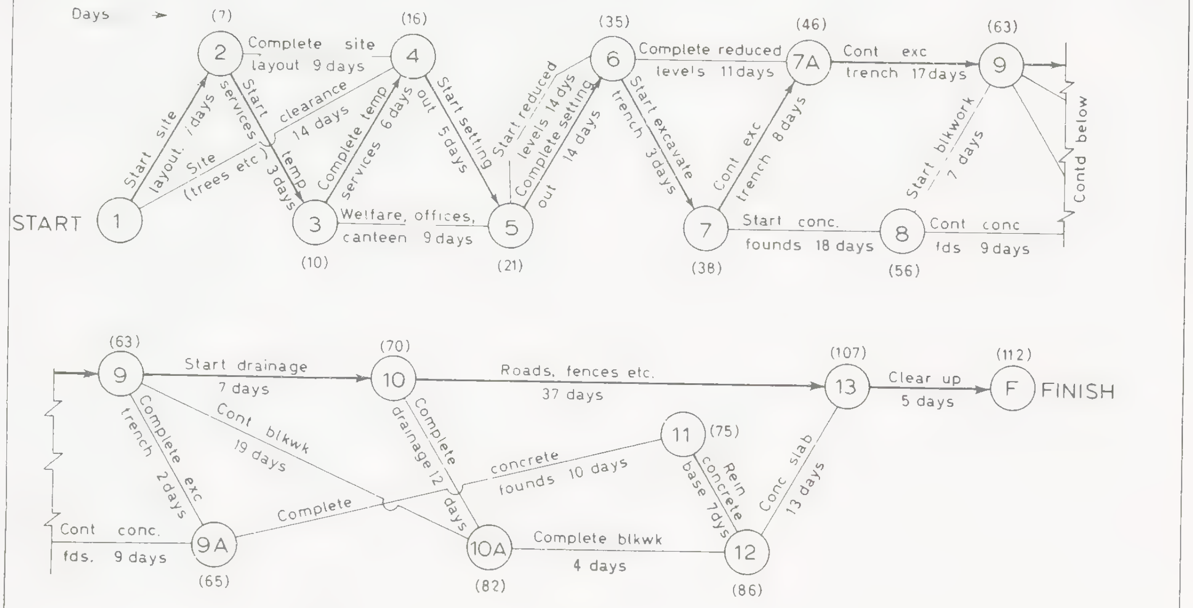

HALL OF RESIDENCE
PROGRESS CHART
CONTRACT No 1
CLIENT
ARCHITECT
DATE OR
WEEK No
DAYS
UNIT
AMT
M HR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
7 14 21 28 35 42 49 56 63 70 77 84 91 98 105 112 119
TIME NOW
FINISH
PRELIMINARIES
SITE LAYOUT 1 - - -
TEMP SERVICES 2 - - -
OFFICES, WELFARE 3 - - -
FOUNDATIONS
SITE CLEARANCE 1 M S 800 1
SETTING OUT 4 - - -
DRAINAGE 9 BLKS 700 M R 300
EXC. RED. LEVELS 5 M C 100 6
EXC TRENCH 6 M C 200 5
CON FDS 7 M C 120 8
R C. BASES 11 M C 10 10
BLKWK TO G.L. 8 BLKS 5000 1/12
CONC. SLAB 12 M C 70 11
ROADS, KERBS 10 M C 10 17
FENCING 10 M C 500 1
CLEAR UP 13 - - -
3000
3000
5000
INDICATOR
LABOUR – ESTIMATED 12 18 12 6 6 13 13 9 11 13 14 10 12 10 10 6
LABOUR – ACTUAL 15 15 15 7 7 15 14 11 11 13 14
PROGRAMMING and PROGRESSING

Fig 8.3



Sketch layout of network

Fig. 8.4

not critical. Temporary services on the other hand will take just as long as the completion of site layout, i.e. 9 days: so either path could be critical. The critical path (arrowed) is shown as passing through events (1), (2), (3) and (4). It could equally be (1), (2) and (4).

Now consider the activities between events (9) and (13). The path (9), (9A), (11), (12), and (13) shows a total of 32 days. But the path through (9), (10), and (13) total 42 days which is critical. Similarly, the path through (10), (10A), (12), and (13) takes 29 days, whereas path (10) to (13) takes 37 days which is critical. The critical path is shown arrowed.

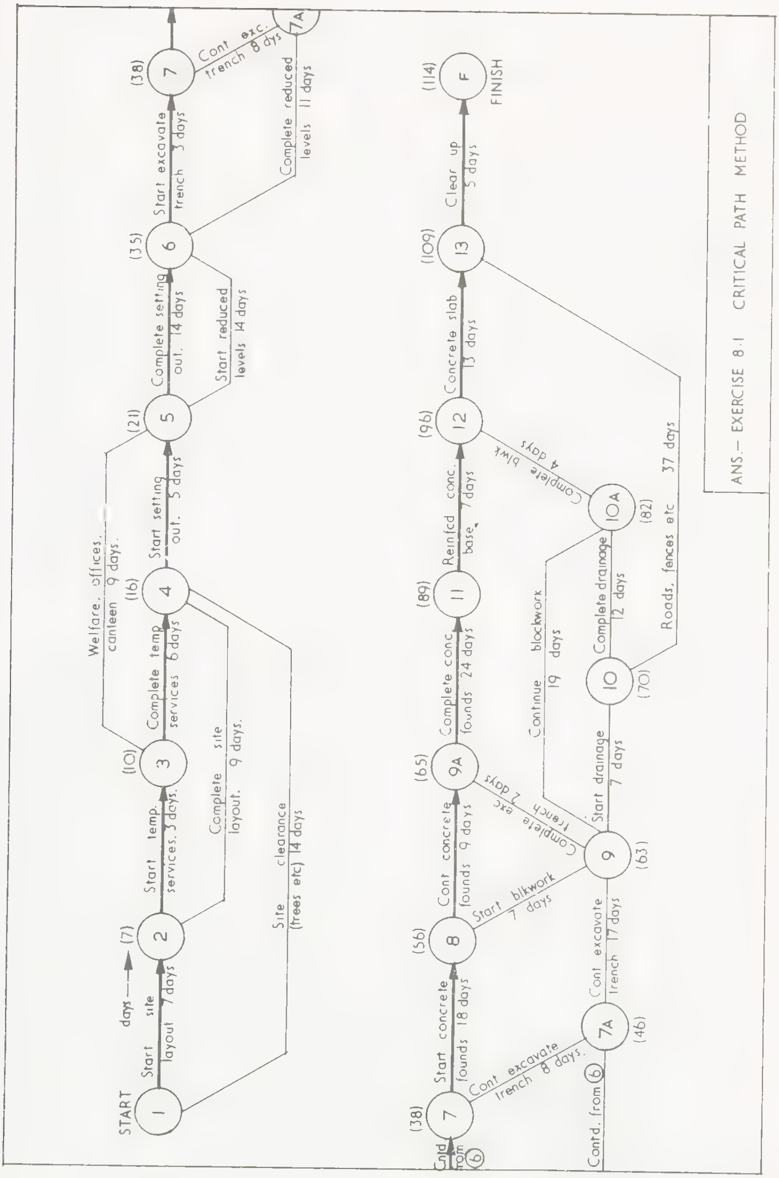
Thus it will be seen that not all delays are significant, inasmuch as they will not affect the finishing date. A delay on any path, however, can make it critical if it exceeds critical path time. Thus any delay in loop activity (5) to (6) or link (6) and (7A) could change the critical path.

The traditional bar diagram, Fig. 8.3, shows a delay of 2 days in the start of the r.c. bases (item 11). The C.P. network, however, shows that this could be extended to 12 days from Day 75 to Day 87 without overrunning the final date, so the delay is not yet significant. The earliest and latest times of starting can be recorded in this way at each event, which is not possible with the bar diagram. The latter, however is simple to follow when working smoothly. Many people like to keep both up to date as a check against each other.

The above description of C.P.M. is essentially an elementary one and more can be done with it than described here. The system can, for example, be used to control costs. Some networks show much more detail and information can be arranged, if necessary, for use with a punch card system or for feeding into a computer. That, however, is not likely to become general practice just yet.

In most tropical countries where sunlight is likely to be stronger than in Europe it is advisable to use a stable method of photocopying prints on good quality paper, and to cover them up when not in use.

Exercise 8.1 Owing to flooding, the completion date for the concrete foundation (event 9A) has been delayed by 14 days. Re-draw the C.P.M. network complete to show this amendment. Show also the critical path as a straight line for the whole network.


START
days ——→
1
Start site layout 7 days
(7)
2
Start temp. services. 3 days.
(10)
3
Complete temp services 6 days
(16)
4
Start setting out. 5 days
(21)
5
Complete setting out. 14 days
(35)
6
Start excavate trench 3 days
(38)
7
Cont exc. trench 8 days
7A
Welfare, offices, canteen 9 days.
Complete site layout. 9 days.
Site clearance (trees etc) 14 days
Start reduced levels 14 days
Complete reduced levels 11 days
Cntd from 6
(38)
7
Start concrete founds 18 days
(56)
8
Cont concrete founds 9 days
(65)
9A
Complete conc founds 24 days
(89)
11
Reinfcd conc. base 7 days
(96)
12
Concrete slab 13 days
(109)
13
Clear up 5 days
(114)
F
FINISH
Cont excavate trench 8 days.
7A
(46)
Contd. from 6
Cont excavate trench 17 days
9
(63)
Start blkwork 7 days
Complete exc trench 2 days
Start drainage 7 days
10
(70)
Complete drainage 12 days
10A
(82)
Continue blockwork 19 days
Complete blwk 4 days
Roads, fences etc 37 days

ANS.– EXERCISE 8.1 CRITICAL PATH METHOD

9 | Developments in Building Methods

9.1 Introduction

The reader should by now have become acquainted with the basic principles of construction and traditional methods of building in the tropics.

A knowledge of the history of building, however, would have taught him that styles of construction are constantly changing with the advent of new materials and methods of erection. Architectural styles are always geared to these essentials. The time-factor is considered most important in most countries and as industrialization increases in the tropics, so will the speed of construction.

The greatest change in building method has probably been brought about by the widespread use of reinforced concrete during the present century. Other changes are also taking place and, although it may be some time before they are firmly established, some knowledge of them is essential at this stage.

9.2 Shapes and their influence on building

The shape and position of a building component in a structure affects its strength, as is well known. The rigidity of corrugated sheet compared with flat sheet is a simple example, Fig. 9.4. A plank of wood laid flat to span an opening will bend much more than if it were placed on edge; in this position, however, it would twist or whip in the same way as a deep joist.

Similarly, a tube or cylinder laid horizontally across a span would support a greater weight than if it were first flattened and then loaded. Further examples of shapes affecting strength could be given by comparing a vertical tube with a solid rod. Should they both be of the same length, contain the same amount of metal, and weigh the same, the cylinder would carry a greater load than the rod which would tend to buckle earlier. There is a limit, however, to the size of the cylinder; it would collapse if the walls were made too thin. The question of shape, then, plays an important part in modern structural design. Figures 9.1 to 9.3 give examples of well known objects: an umbrella, an eggshell, and an electric light bulb, where shape is utilized to provide the necessary strength.

The object of the designer in many cases is to obtain maximum strength or coverage with the minimum of material or, as one famous dome builder puts it:

'to do more with less'.

This concept has resulted in new shapes and methods of construction and some of these will now be considered.

SPACE STRUCTURES. Triangulation of members to give rigidity has already been discussed and examples of this may be found in roof trusses, Volume 1 and Volume 3. These trusses show a method of spanning distances by using frames in two dimensions. Deep frames over large spans have a tendency to whip or buckle and are sometimes stiffened by using latticed purlins, as shown in Fig. 9.10a.

In recent years, as spans have increased, the tendency has been for trusses and frames themselves to be triangulated, Fig. 9.10b, and further stiffened by use of *latticed purlins*. This system results in a very rigid structure.

An effective form of roof is the *scissor* shape shown in Fig. 9.11. This not only provides adequate protection against sun, if correctly orientated, but also permits roof ventilation without allowing rain to enter. A study of the drawing will show how this is possible. The trusses in this case are of r.c. with central purlins supporting the glass and louvres. The longitudinal beam supporting the trusses also acts as the gutter.

Three-dimensional bracing in modern structures is quite common today and a simple example of a space frame is given in Fig. 9.12. This may be of metal, timber, or r.c., although the last is unusual. Tubes, angles, rods or flats, or any combination of these can be used as desired and large spans bridged in this way. A further development is to cover areas rather than spans by triangulated frames as shown in Fig. 9.13. Maximum rigidity in all directions is achieved by this method. The frames are light to handle and large areas of them can be erected quickly by using prefabricated panels hoisted into position with a mobile crane. Cold pressed steel or aluminium channels, tube or rod are the most usual materials for this type of construction (see Volume 3). For the sake of clarity only a few stays have been shown.

The pitch is usually kept quite low to simplify erection and permit standardization; the fall is obtained by the use of cleats supporting purlins. Long-span aluminium corrugated sheets are frequently used to overcome the lapping problems which are usual with flat pitches. Aluminium is also light and durable.

GRIDS. Grid structures are also used for covering large areas; these are similar in function to space frames. In their simplest form, however, they are usually of egg crate design and constructed of timber, r.c., or lattice beams. Square grids of solid members are popular and the principle is not only confined to floors and roofs. Figure 9.5 shows how a building may be considerably stiffened by this method which is commonly termed 'cross-wall' construction. It is mainly suitable for blocks of flats where small units are needed which are not likely to require alteration in later years. Square grids are not as rigid as diagonal types: the latter, however, can be more costly in the construction of horizontal surfaces and are not much used for this reason, unless extra rigidity is needed.

The use of grids is not confined to flat surfaces only. They are readily adaptable to *barrel vaulting*, for instance, Fig. 9.14, and large spans can be covered in this way without the use of intermediate supports. They are frequently used for transport depots, aircraft hangars, and similar structures. Where the whole of one side of such a building needs to be left open for continuous access without obstruction, it is customary to use a *space framed truss*, Fig. 9.12, designed to resist both excessive sag and lateral thrust from the vault itself.

One well known system of grid construction on this principle is the 'Lamella'. This enables the grid to be made up of short pieces of timber, each member being twice the length of one side of the diamond. Jointing is easy and large spans can be covered in this way.

GRID DOMES. For thousands of years domes have been used to cover large areas without intermediate support. The most famous of these is probably the Pantheon in Rome which is nearly 2000 years old. Other famous domes are St. Peter's, Rome, the Dome of Florence, and

Shapes affecting strength

Fig. 9.1 Strength in membranes

Figs. 9.2 and 9.3 Strength in shells

Fig. 9.4 Strength in corrugations

Fig. 9.5 Cross-wall construction

Fig. 9.6 Curved corrugated construction

Fig. 9.7 Intersecting barrel vaulting

Figs. 9.8 and 9.9 Hyperbolic paraboloids

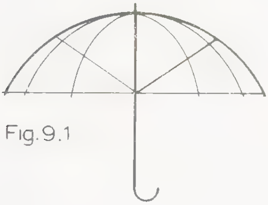


Fig. 9.1

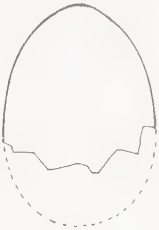


Fig. 9 2

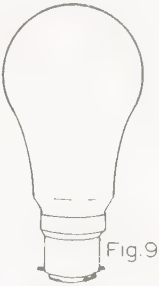


Fig. 9.3

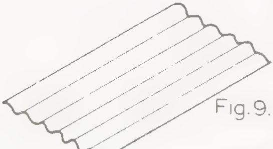


Fig. 9.4

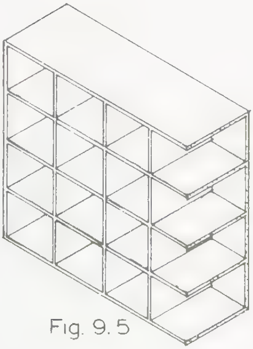


Fig. 9. 5

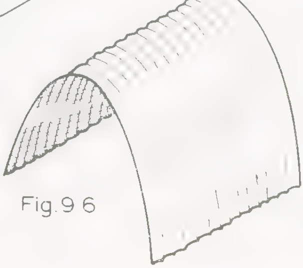


Fig. 9 6

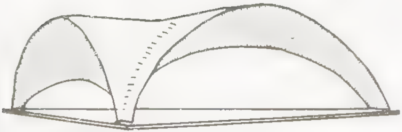


Fig. 9 7

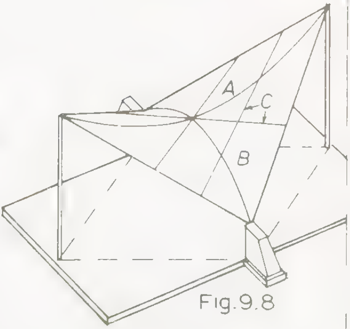


Fig. 9.8

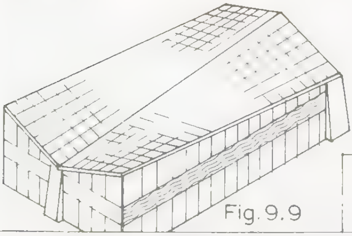


Fig. 9.9

SHAPES AFFECTING STRENGTH

St Paul's, London. In many hot dry climates dome building is a masterly art where sun-dried blocks are extensively used, often over quite large spans with pendentives springing from square bases. These are skilfully built without the use of centering or cement and using only a single radius rod. Block courses are built up in concentric rings in wet soil mortar; adhesion is due to the intensive suction caused by the hot sun (see Volume 1).

These domes, however, cannot compare for sheer size and lightness with the domes of modern materials. The use of light alloy ribs made into triangulated units and covered with a waterproof skin enables domes of great size to be built very quickly. The *geodesic domes* of Professor Buckminster Fuller are famous the world over, and the principles of design may be found in the relevant textbooks. They are usually built as a part of a sphere with the basic unit as a triangle. These are assembled into hexagons and pentagons and put together in such a way as to form a complete cap with no internal obstructions. Once the frame has been erected, the covering can be of any waterproof material such as fibreglass, plastic sheet, resin-bonded plywood, or aluminium sheet.

The frame is frequently made of aluminium alloy and the ribs shaped to give maximum strength. They are cheap and easy to erect, and much sought after for use as concert halls, stadiums, exhibition halls, etc. On large domes the polygons, instead of being built up of flat triangles, see Fig. 9.15, may be stiffened by the insertion of a central

Trusses and frames

Fig. 9.10 Triangulated frames

Fig. 9.11 Scissors roof

Fig. 9.12 Three-dimensional bracing

Fig. 9.13 Space frame

Fig. 9.14 Grid barrel vaulting

Fig. 9.15 Grid dome

Fig. 9.16 Trussed polygon

Fig. 9.17 Domed shell

Fig. 9.18 Folded slab

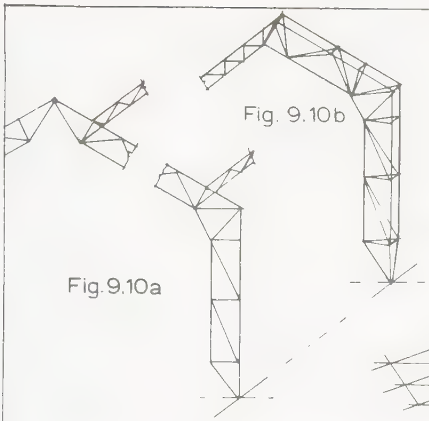


Fig. 9.10b

Fig. 9.10a

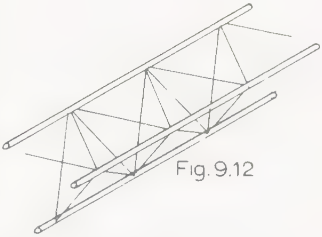


Fig. 9.12

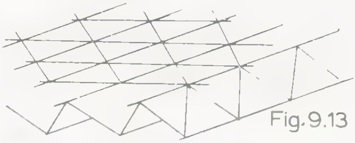


Fig. 9.13

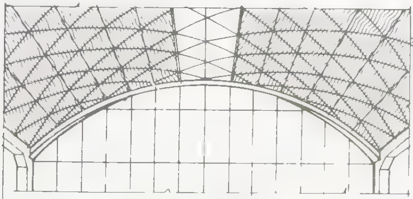


Fig. 9.14

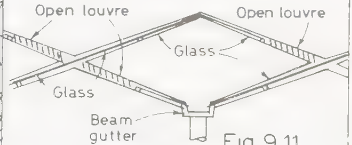


Fig 9.11

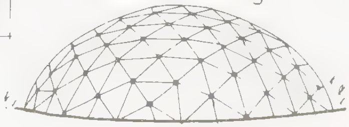


Fig. 9.15

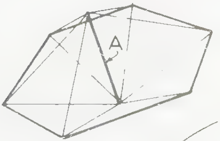


Fig. 9.16

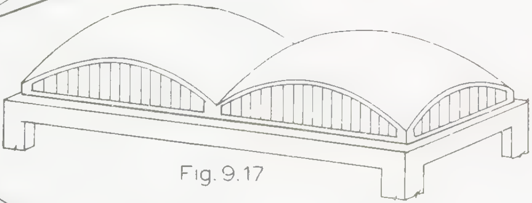


Fig. 9.17

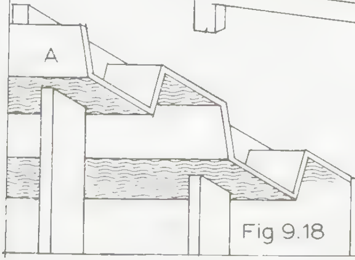


Fig 9.18

TRUSSES and FRAMES

prop, *A*, linked to the corners by ties, Fig. 9.16. Alternatively, two polygons may be used, one above the other, held apart by braces meeting at a central point.

PRESTRESSED CONCRETE. As the reader may have inferred from what has been written, concrete in tension is relatively weak, hence the care that is necessary when placing reinforcement in the position shown on the drawings. In concrete beams, for example, the weakness may, in certain cases, be overcome by placing cables or rods through the concrete on the tensile side and stretching them by means of hydraulic jacks. While in this state of tension they are firmly anchored against the ends of the members. This causes the tensile area of the concrete to be put in compression which, on loading, is relieved of its compressive force to become neutral.

A usual method on site is to cast the concrete member first and leave longitudinal holes through which the cables may be passed. One method of forming holes is to place well-greased rubber sleeves in position and cast the concrete beam around them. The sleeves are pulled out after the concrete has set. The wires or bars are then threaded through and stressed against the concrete ends. This method is known as post-tensioning as the cables are stressed after the concrete has been cast. The space around the cable is then filled with cement grout injected under pressure.

Precast concrete members are now becoming more widely used in structures, (see Vol. 3). Sometimes these are prestressed in concrete factories. Where there is much repetition, this can be done quite cheaply by stretching wires over beds hundreds of metres long and casting the beams around them. When set, the wires are cut. Long members such as beams, piles, and lamp standards can be made in this way.

Prestressing permits long spans to be covered, using very small sectional areas, and the graceful spans of many concrete bridges are often achieved by prestressing. This method is also used for slabs, water towers, tanks, railway sleepers, columns, and concrete ties of all descriptions.

Great care has to be exercised in every stage of prestressing, particularly in the quality control of the concrete, and expert supervision is needed on site for large-scale work.

DOME SHELLS. Domes built up as grid structures, although popular, are not the only means of construction by modern methods. Many interesting developments have been made possible by using geometrical principles involving conic and spherical sections and by the use of new materials.

Shapes of parts of spheres are often used in structures covering large spans. These can be rectangular, polygonal, or square on plan. Sometimes two or more domes can be connected, particularly where internal supports are not objected to, Fig. 9.17.

The most usual method of forming domes, barrel vaults, and double-curved roofs is by means of concrete shells 50 mm to 75 mm thick. Where spheres are cut, as in Fig. 9.17, or where barrel vaulting is concrete covered, edge beams have to be strong enough to resist outward thrust. Prestressing is frequently used for this purpose.

DOUBLY CURVED ROOFS. Shell roofs of thin membranes are now frequently used, due to their lightness and economy when constructed over large areas. The most common form of doubly curved shell is that of a *hyperbolic paraboloid* (H.P.) shown in Figs. 9.8 and 9.9. It is so called because the double curve may be sectioned to give a parabola in one plane and a hyperbola in another.

In Fig. 9.8, the broken lines lie on a horizontal plane. The edges of the doubly curved surface are directly above these lines which form the plan. The principle may be simply described as follows. Imagine the four edges acting as members in compression. They would then thrust against the blocks at the lower corners. This compressive thrust could be applied by pulling down on the upper corners. The *catenary A* looped between the upper corners, however, could not straighten out as it would be held by the inverted catenary *B* between the blocks. As these forces must always be equal, it is only necessary that either the compressive force in the blocks or the tensile force in the ties be met, but not both. It is normal practice to supply buttresses at the lower corners and make the edge beams strong enough to resist compression.

A big advantage of using H.P. roofs is that equidistant points on opposite sides of the roof may be joined by straight lines, *C*, Fig. 9.8. This enables formwork to be erected quite simply by fixing straight boards in narrow widths. Timber shells are also made on this principle.

Numerous shapes can be built up by combinations of H.P. shells, and Fig. 9.9 shows a typical example using two slabs. Buttresses have been placed at the lower corners. In practice the rise of the upper corners should not exceed a quarter of the span.

Figure 9.7 shows an interesting example of *intersecting barrel vaulting*. It is not, of course, a doubly curved shell.

FOLDED SLABS. It has already been shown that a corrugated sheet is more rigid than a flat one. This applies to all sizes of slabs, whatever the material, and this property is often made use of in modern design.

A parabolic vault as shown in Fig. 9.6 may be designed using this principle and a very stiff shell will result. The principle may also be applied to barrel vaulting, shell domes, walls, roofs, sheet piling, and retaining walls. The folds may be made in many ways and not confined to corrugations. Flat surfaces are cheaper to construct than curved ones. Figure 9.18 shows a popular use of folded slab construction. The supporting beams may be above or below the slab as desired. In addition to providing strength to the roof, this method provides a ready means of lighting the interior by means of openings in the side walls. The roof profile may also be of saw-toothed shape if preferred. Longitudinal edge beams must be provided, however, at the free edges to resist lateral thrust from the slab. This may consist of a normal beam or the slab itself may be cantilevered to act as an inclined beam as shown at *A*.

9.3 Industrial systems

With the rapid expansion of the building industry after the last war attention was focused on finding more speedy methods of production than was possible by traditional means. Mass production of repetitive units and components, mainly of concrete, were considered to be the answer and such methods are now fairly numerous. All rely largely on factory-made components of a standard pattern. They are capable of speedy erection which is usually done by tower or mobile crane. The most widely used systems are those which adopt precast components factory-cast to fairly close tolerances. These are hoisted into position on site and jointed together. Other methods are also discussed in Volume 3.

Many tropical countries are not yet ripe for the introduction on a large scale of prefabricated systems of building. Their use is increasing in industrial areas, however, and a few words on the subject are necessary here.

Structural systems of building based on precast concrete units often consist of walls of room height, with floors and roofs usually spanning the full width between the supports. Window and door openings are usually incorporated at the time of casting; lifting holes and lugs are positioned for easy handling and jointing methods carefully worked out.

The site organization needs to be carefully planned. The cast units are normally handled by a mobile crane and the rate of delivery from the casting yard is geared closely to the estimated speed of erection on site. A diagram of progress is prepared in advance on the lines described in the last chapter but in greater detail.

Where large buildings are to be erected in this way, the casting yard is put into operation while the foundations are being dug. Casting starts a few weeks before erection to permit curing and allow some stock piling. Internal partitions, built-in furniture, room dividers, and similar items are usually made early and stored ready for lifting into position. Prefabricated plumbing and service units are sometimes prepared ready for installation as the work proceeds: conduits are provided in walls and floors to connect them. Usually internal plastering is not required, as the modern trend is to eliminate wet trades, i.e. plastering, masonry, etc. Spray plaster techniques are, however, widely used to give variety to wall finish.

Other systems for multi-storey building comprise precast slabs assembled into conveniently sized box or angle components in a factory, transported to site, and put together in position to form a complete unit. Precast stairs are also fixed at the same time, (see Volume 3).

External prefabricated panels may, of course, be of material other than concrete. Cladding or curtain walling are widely used with prefabricated structural systems. Timber can also be admirably adapted for this purpose. Volumes 1 and 3 show one or two systems.

Structural steel is widely used in system building, particularly in space structures. These can be framed and clothed complete and lowered into position by crane. Whole floors, for instance, can be treated in this way.

Though tower blocks and high-rise flats are no longer built in some countries, a lot of work is still being done and research and development cover a whole field of industrialized, prefabricated, or system building. The main object is the saving of time and labour, particularly where the latter is in short supply. As this may not apply in many tropical lands, the advantages may well be lost. In many instances, too, prefabricated systems are more costly than traditional methods, partly because the amount of repetition does not justify the initial outlay in mould and jig making and preparation. Problems also arise in finding sufficient capital to launch schemes, float new systems, and keep factories at full production. The question of availability, transport problems, and the reaction of customers to new styles must also be considered. Dimensional co-ordination of components is essential and so is accuracy in their assembly. As the pace of building grows, however, mass-produced items could find a greater share of the market.

Industrial and domestic light buildings, factory-made and delivered to site have been in use in Europe for many years. Large numbers were built this way immediately after the war, but they are now more sophisticated. A number of firms make prefabricated light buildings complete, finished and painted ready for occupation. In one system the walls are folded flat between the roof and the floor. Erection is effected simply by raising the roof. The use of timber for prefabrication is increasing in many countries.

A number of firms also make tropical and sub-tropical insulated dwellings of glass fibre products which can be rapidly assembled with simple tools and unskilled labour. The Building Research Establishment, Tropical Division and Overseas Building Notes can supply useful information.

9.4 Tall buildings

Most capital cities which aspire to industrial importance have at least one tall structure which can lend prestige to its environment and engender civic pride. This, however, is not the object of tall buildings; it is usually one of expediency.

Tall buildings are not necessarily economic. There is an economic height of a structure, just as there is an economic speed of building. As land values increase and firms or organizations expand, so buildings tend to become taller. There are some in existence which are over 300 m high, and 100 m structures are by no means rare. High-rise blocks of flats were used in the 1960s to solve housing problems in Europe but are now rarely built, largely for social reasons.

There are problems connected with tall buildings which must be overcome during the design stage. Standardization is important; economic repetition of components and simplicity of erection is essential if speed of erection and low cost is to be achieved. Jointing has been discussed in Volume 3.

Prefabrication can effect savings, particularly where components can be produced in large quantities with as few types as possible. The choice of materials is also important. Light, strong substances are usually sought after, especially where foundation problems are likely to be encountered. Aluminium alloy k.d. for shipment or glass fibre cement sprayed on framework are being increasingly used. The system is also important. Grids are mostly in favour in order to give maximum rigidity and aluminium or cold-formed steel sections are often in demand for this reason.

A big factor to be considered in high building is wind, and by-laws and Codes of Practice lay down established formula for determining wind resistance from known data, (see Vol. 3). Tower blocks are not affected in the same way as wider-fronted tall structures which can create special problems of down draught. Bracing against wind can involve complex design. The structure must, of course, be safe against overturning (grain silos have been known to do this) and also against excessive sway, which can cause distortion inducing cracking and destroying weather-tightness. Deep mullions in tall buildings serve two purposes in warm climates: they not only provide direct support and resist horizontal thrust but also serve as sun-breakers.

Temperature movement of structures of any material including r.c. has to be allowed for and calculated to fairly close limits. Expansion joints and their position, both horizontal and vertical, must be allowed for. Services, too, play a large part in the smooth functioning of tall buildings. Lifts, communications, and passenger movement need to be considered in detail. Ventilation, catering, plumbing, and fire prevention are other matters needing detailed investigation.

The problems raised in this chapter are for the more advanced reader and some have been dealt with in Volume 3. New methods, materials, and ideas are constantly being thrown up and continual study is necessary to keep abreast of current practice.

This book, however, will have given the reader some knowledge of basic construction and, as all new methods retain something of the old, progressive study of the subject should not prove too difficult.

Guide to further reading

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Book lists

A comprehensive catalogue of books for the construction industry as a whole is published annually by the *Building Bookshop.*

An annual *RIBA book list* is also available to architects and students.

Sources of information

The Building Research Establishment (B.R.E.), England, produces an *Information Directory* annually, which includes a complete list of current government publications on building activities and requirements, materials, elements, and the built environment. It also gives useful information for developing countries including *Overseas Building Notes* and lists its Overseas Agents.

The Department of the Environment (D.O.E.) also publishes a leaflet annually called *How to find out*, which gives details and sources of information selected from 550 organizations in the construction industry.

All the above lists and catalogues may be obtained direct from The Building Centre, 26 Store Street, London WC1E 7BT.

Glossary

acrylic resin: Synthetic resin of the thermoplastic type made by polymerization of an acrylic compound (B.S. 2015, 1965).
air bunching: accumulation of air around a ventilator due (usually) to the inadequacy of the extractor.
air-conditioning: The simultaneous regulation of the following factors affecting atmosphere within the structure: (a) temperature, (b) humidity, (c) ventilation. In addition factors such as distribution, dust, bacteria, odour, and toxic gases may also be controlled (B.S. 1584, 1949).
alternating current (a.c.). An electric current which alternately reverses its direction in a circuit in a periodic manner, i.e. has an alternating waveform (*see* B.S. 4727, Pt.1, 1971 for fuller definition).
aluminium paint primer. Primer containing a proportion of aluminium pigment to be distinguished from aluminium paint in which the aluminium is designed to float to the top giving metallic brilliance (*see* B.S. 2015, 1965 for fuller definition).
ambient air temperature: The prevailing temperature of the atmosphere surrounding the component under consideration (B.S. 1584, 1949).
anode: An electrode which receives electrons or negative ions (*see* B.S. 4727, Pt. 1, 1971).
arc: A form of gas conduction characterized by a relatively high current density (*see* B.S. 4727, Pt.1, 1971 for fuller definition).
automatic flushing cistern: A water cistern mainly used for flushing urinals automatically at predetermined periods.

bar diagram: Alternative name for progress chart.
basement: A storey wholly or mainly below ground level (B.S. 3589, 1963).
binding wire: Soft wire used generally for tying reinforcing bars.
bi-parting doors: A door which slides vertically and consists of two or more sections or pairs of sections that open away from each other and are so interconnected that two or more sections operate simultaneously (B.S. 4727, 1971).
bottle trap: Deep seal trap so called because of its shape.
bungalow: A house of one storey.

calcium plumbate primer: Paint used for the first (priming) coat on galvanized iron.
candela: Unit of luminous intensity (*see* B.S. 4727, Pt. 4, 1971 for fuller definition).

chromating: Treatment of light alloys by chemical solutions normally containing chromatic acid and/or chromates in a suitable acid medium. This treatment modifies the surface to give improved protection against corrosion and to serve as a good base for subsequent coats (B.S. 2015, 1965).

component: A section unit or compound unit (B.S. 3589).

condensate: Water of condensation.

condenser: A vessel or system of tubing in which the compressed refrigerant gas is liquefied by the removal of heat (B.S. 1584).

crawlway: An underfloor space providing access to ducts, pipe and other services hung or laid therein and of a height sufficient for crawling (B.S. 3589).

crossfall: Slope of road from one side to the other.

cross-wall construction: A type of construction in which floor and roof loads are carried entirely on walls running across a building.

current: The flow of electricity along any path or around any circuit.

daylight factor: Ratio of daylight received from the sky at a given point (*see* B.S. 4727, Pt.4, 1972 for fuller definition).

decking speed: The reduced speed within a limited zone prior to stopping level with the lift landing. This is usually controlled by an automatic car-levelling device which operates independently of varying loads (*see* B.S. 4727).

dehumidifier: An apparatus for removing moisture content from a substance either by precipitation on reduction of temperature or by the use of a hygroscopic substance (B.S. 1584).

dewatering: Drainage of large areas usually by means of special equipment.

diffusing panel: *See* B.S. 4727, Pt. 4, 1972.

dimensional co-ordination: Agreement made between the manufacturer of building units and the designers in order to simplify assembly by standardizing sizes.

direct current: An electric current flowing in one direction only and free from pulsation or periodic variation (*see* B.S. 4727, Pt.1 for fuller definition).

dome light: A dome of glass or plastic, normally saucer shaped and in one piece, up to about 2 m in diameter placed over an opening in a flat roof.

doubly curved shell: A shell, usually an H.P. roof, curved in two directions (*see* Vol. 1).

dovetail housing joint: A housed joint in which the edge of the housed member is cut to a dovetail shape in section and the housing in the supporting member is undercut to correspond so as to resist any tendency for the housed member to pull out of the housing (B.S. 565, 1972).

dwarf wall: A low wall, normally built below a ground floor of a dwelling to support it.

efflorescence: Development of crystalline deposit on surface of brick, cement, etc., caused by soluble salts.

electric field: A physical state between static electric charges of opposite sign and in separate positions characterized by forces acting on other electric charges either at rest or in motion (B.S. 4727, Pt 1, 1971).

electrode: A conductor through which current passes to or from a medium (*see* B.S. 4727 for fuller definition).

epoxy resin: Synthetic film containing epoxide groups and in which the final polymer is formed as a result of a reaction taking place substantially at the epoxide group (B.S. 2015).

etching: The production of a uniform matt finish by controlled chemical or electro-chemical attack (B.S. 3660, 1976).

evaporative condenser: A compact form of condenser in which air is positively directed over a surface by mechanical means (B.S. 1584).

expansion valve: A valve for controlling the flow of liquid refrigerant to the evaporator (B.S. 1584).

flight: Continuous series of steps from one floor landing or set of winders to another (B.S. 565).

flynut: A loose nut used to make a union joint in pipework.

foamed plastic: Synthetic resin, usually polyurethane, expanded into lightweight filling used for insulation purposes.

freezer: A low temperature cold store normally maintained below minus 6°C.

fungicidal primer: Paint treated in manufacture to resist fungal growth and mould.

fusible plug or link: A safety device consisting of an alloy of low melting point designed to release pressure at a predetermined temperature (B.S. 1584).

fuseway: An electrical circuit with its own main fuse.

gaskin: A gasket of tow or hemp fibre used for caulking the socket of stoneware pipes before mortar filling is inserted.

geometrical stair: A continuous staircase curved on plan constructed around a stairwell.

glazing: (1) Enrichment or modification of a painted surface by application of thin, translucent coloured coating (B.S. 2015); (2) The act of fixing glass in a frame.

going: The distance from face of riser to face of riser in a staircase (B.S. 3589).

grid: A rectangular network of lines in planning or setting out.

grit (or sand) blasting: The projection of abrasive grit so as to strike the surface of an article providing a cleaning action and producing a matt finish (B.S. 3660, 1976).

hot cathode tube: Tube in which the cathode is heated in order to agitate and eject electrons out of the electrode.

illumination lighting: Application of visible radiation to an object (B.S. 4727, Pt.4, 1971).

immersion heater: An appliance containing an electrically-heated resistor for raising the temperature of a liquid in which it is immersed (B.S. 4727).

infill pads: Pads of lightweight material placed in frames or receptacles to improve insulation.

ion: An electrically charged particle derived from an atom or group of parent molecules (*see* B.S. 4727, Pt.1, for fuller description).

jib: Projecting, swinging arm of a crane either horizontal or inclined.

kerb: A low barrier rising above the surrounding surface (B.S. 3589).

knotting: Quick-drying composition used in joinery to form an impervious covering for knots, usually consists of shellac in industrial methylated spirit (*see* B.S. 2015 for fuller description).

lagging: (close): In centering, battens fixed close together to the top of the ribs to form a lining to support brickwork, stonework, or concrete until set (B.S. 565).

landing: A platform at the termination of one or more flights of stairs (B.S. 3589).

lift well: The space to accommodate a lift (B.S. 3589).

lobby: A circulation space into which one or more rooms open. A small vestibule (B.S. 3589).

light meter: A device for measuring brightness.

lumen: SI unit of luminous flux. (*see* B.S. 4727, Pt.4, 1971 for fuller definition)

multi-point heater: Water heater supplying more than one tap or outlet.

nomogram, daylighting: A chart, published by B.R.E. England, for determining the indirect daylight component necessary for finding the total daylight factor.

nosing: The projecting edge of a tread, or board often rounded (B.S. 565, 1972).

oildraulic: A coined expression meaning operated by oil, not water power.

one-pipe system: A system of soil and waste water disposal using two vertical pipes: waste and soil fittings discharge into the one stack connected directly to the drain, the other pipe is used for ventilation and antisiphonage.

partition: A wall whose primary function is to divide space within a building or structure (B.S. 3589).

pitch: The angle of slope to the horizontal (B.S. 3589).

pitch-fibre pipe: A drain pipe usually made from wood-fibre pulp impregnated under vacuum with coal tar pitch to about 75 per cent of its total wieght.

plasticizer Substance added to mortar to concrete to increase workability.

plate. A horizontal member supported along its length and in turn supporting other members (B.S. 565).

polyurethane: A lightweight foamed plastic used chiefly for insulation purposes.

P-trap. Usually a w.c. pan trap so called because of its shape and to distinguish it from an *S*-trap.

pole (electrical): An electrode or terminal.

prefabricated. Fabricated on or off site before incorporation into a building or structure.

primer: The first complete coat of paint applied to an unpainted surface (B.S. 3589).

public building: A building used principally for public assembly or public service (B.S. 3589).

raker: An inclined beam (B.S. 3589).

reduce level: To excavate to a lower level at which operations will commence.

refrigerant. The medium for conveying heat in a refrigerating system being evaporated by absorbing heat at a lower temperature and liquified by surrounding heat at a higher temperature (B.S. 1584)

refrigerator Any container or apparatus provided with means for being cooled (B.S. 1584).

resistance: That property of a body by virtue of which it resists the flow of electricity through it causing a dissipation of electrical energy as heat (*see* B.S. 4727, Pt.1 for fuller description).

retaining wall: A construction providing lateral support to the ground or a mass of other material (B.S. 3589).

reveal: The vertical face revealed in the thickness of an opening or the depth of a recess (B.S. 3589).

riser: The vertical (on section) member of a step (B.S. 565).

rodding eye. An access point in a drainage system through which drain rods can be passed in order to clean out pipes or remove obstructions

saddle (tower cranes). The traveller on the horizontal jib of a tower crane from which the hook is suspended.

saponification: Decomposition of paint film by alkalis and moisture in a substrate; takes place usually on new concrete and renderings (*see* B.S. 2015 for fuller description).

saw-tooth roof: A series of north light roofs (B.S. 3589).

single-stack system: A system of soil and waste disposal using a single pipe and waste branches with deep-seal traps to prevent antisiphonage; so named to distinguish it from one-pipe and two-pipe systems.

single phase: A qualifying term applied to a system or apparatus to denote one in which there is a single alternating voltage (*see* B.S. 4727, Pt.2 for fuller definition).

storey: The space between two floors or between a floor and a roof (B.S. 3589).

standardize: To make building components and products which conform to standards laid down by appropriate government institutions or other authorities approved by both producer and consumer (*see* also dimensional co-ordination).

tarmacadam: A graded stone mixture coated with tar, spread on a prepared foundation in one or more courses and rolled until compacted.

tell-tale: A thin strip of glass cemented across a crack in a structure which would denote movement by breaking.

three-phase: As for single phase but in which there are three alternating voltages (*see* B.S. 4727, Pt.2 for fuller description).

tread: The horizontal member (on section) of a step (B.S. 565).

tropicalize: To treat machinery and, in particular, sensitive equipment for protection against tropical conditions.

undercoat: Coat of paint after priming.

vapour barrier: (1) A waterproof skin (e.g. bitumenized paper or felt) employed to prevent moisture absorption by an insulant, by capillary attraction or difference of vapour pressure (B.S. 1584).

veranda: The covered outdoor space for sitting or walking, open on one or more sides, extending from a building (B.S. 3589).

water closet: A room in which one or more w.c. pans are installed.

watt: The practical unit of power.

wrot: Planed on one or more surfaces (B.S. 565).

Index

Accelerator, 25;
acoustic panels, 51
acrylic resin domes, 71, 211
adhesives, tile, 33
adobe, 176
air bunching, 76, 211
air conditioning: air cleaning 97; chilled water, 97; control mechanism, 77; distribution, 95; ducting, 77, 95; function, 211; humidifying, 98; insulation, 95; packaged, 96; principles, 94; refrigerants, 94, 98
ambient air temperature, 77, 211
alternating current, 89, 211
aluminium: doors, 36; finishes, 36, 54; paints, 65, 211
anodizing, 40
arc, 88, 211
arch: centering, 152; shoring, 144
asbestos cement fibre, 60

Bag plug, *see* expanding plug
balustrading, 12, 14
balconies, 5
bamboo lathing, 28, 176
bar diagram, *see* progress charts
basement, 146, 211
baths, 127
bidets, 127
bitumen: block, 181; rendering, 181; soil, 181
blinds, Venetian, 56
blocks: foamglass, 35; glass, 35; soil-cement, 179
block-making machine, 174
bungalow, 90, 152, 211
buying department, 188

Calcium plumbate, 66, 211
candela, 82, 211
canopies, 51
cartridge guns, 57
catering equipment, 104
ceilings, suspended, 51
centering, 152
ceramics, mosaics, 31, 32
cesspools, 118
cisterns: cold water, 129; flushing, 128, 211
cob, *see* soils
cold storage, 50
cold water supply: cisterns, 129; copper, 129; meters, 129; piped supply, 128; polythene, 130, P.V.C., 129; rising main, 128; sources, 128; storage, 128
collapsible doors, 40
colour lighting, 83
components, 206, 212
compressors, 169
concrete: blocks, 161, 174; channel, 131; footpaths, 153; mixers, 161, 172
condenser: evaporative, 96, 213; function, 95, 96, 99, 212
contract drawings, 190
copper tubes and fittings, 129
cranes: tower, 168; saddle, 168, 215
crawlway, 99, 212
critical path method, 193
cross wall construction, 200, 212
current, 88, 212
curtain track, 56

Daylight factor, 82, 212
daylighting, 82
dehumidifier, 98, 212
development in building, 198
diffusing panel, 54, 212
dimensional co-ordination, 207, 212, 216
direct current, 89, 212
dome lights, 71, 212
doors: bi-parting, 101, 211; closers, 60; flush, 35; sliding, 36
doubly curved shells, 205, 212

drainage: cesspools, 118; culverts, 109; dewatering, 186, 212; manholes, 113; pipes, 112; rodding eye, 114, 215; septic tank, 114; setting out, 114; sewage, 109; soakaways, 112; soil stacks, 118, 214, 216; testing, 114
drawing office, 185
drinking fountain, 128
drives and footpaths, 153
dry partitions, *see* partitions
ducting, 51, 95, 99
dumpers, 166

Efflorescence, 26, 42, 213
electricity: cables, 89; circuits, 90; consumer supply units, 90; current, 88, 212; earthing, 89; electrodes and hot cathodes, 87, 213, 214; field, 98, 213; fuseway, 90, 213; installation, 90; outlets, 91; phase, 89, 216; pole, 92, 215; resistance, 89, 215; safety, 94; watt, 88, 216
emulsion paints, 66
epoxide resins, 10, 30, 213
escalators, 103
etching, 36, 213
excavators, 164
expanded metal, 28
expanding plug, 114
expansion: joints, 33; valve, 95

Fans, 76
fencing, 152
finishings, 5, 42, 64
fire escapes, 5, 22
fire precaution, 5
fixings, 57
flights, 4, 213
flyscreens, 33
flynuts, 132, 213
floor tiling, 10
flush doors, 35
foamed plastic, 44, 97, 213, 215
foamglass blocks, 50
folding doors, 40
folded slabs, 205
food services, 65, 103
footpaths, 153
foundations: equipment, 164; soil, 180; underpinning, 144, 148
freezer, 99, 213
fungicidal primer, 65, 213
fuseway, 90, 213
fusible links, 60, 213

Gaskin, 119, 213
glare, 83, 86
glass: coloured plate, 35; panels, 35, 213; patterned, 35; sheet, 43
glazing: double, 38; paints, 66, 213
granolithic, 6, 10
grid structure, 199, 213
grilles, 35, 61
grit blasting, 64, 213
grouting, 57
gypsum: mixes, 31; panels, 44; plasters 25; plasterboard, 29, 31, 51

Handrails and balustrades, 12
hand tools, 170
headroom, 4
heat insulation, 44
hoists, 169
hot cathode tube, 87, 214
hot water supply, 130
humidity, 98
hyperbolic paraboloid, 205, 212

Illumination level, 84, 214
immersion heater, 92, 214
industrial systems, 206
infill pads, 51, 214
insulation, heat, 44
internal finishes, 24
internal room divider, 40, 42
internal joinery, 35, 42
ion, 87, 98, 214
ironmongery, 51

Jib, 168, 214
joints: copper, 129; dovetail housing, 13, 212

Keene's cement, 25
kerb, 71, 156, 214
key, 30
kitchens: cleanliness, 106; planning, 106; unit, 42; ventilation, 107; wall fittings, 106

knotting, 67, 214

Ladders, steel, 22
lagging, 152, 214
lamps: colour, 87; fluorescent, 87; incandescent, 86; mercury, 88; sodium, 88
landings, 4, 103, 214
lathing: wood, 28; metal, 28
lighting: artificial, 84; brightness, 83; glare, 83, 86; lumens, 82, 84, 214; meters, 85; natural, 82; needs, 83; roofs, 71; windows, 83, 84
lifts, 102, 103, 212, 214
lime, 24
live fencing, 153
lobby, 5, 214
louvres, lighting, 51
lumen, 82, 84, 214

Machines and manual labour, 159
marble, 33
materials, 24, 129, 188
mechanical plant: cost, 159; factors, 161; labour, 160; maintenance, 160; schedules, 189; types, 161
mercury lamps, 88
metal lathing, 26, 29, 31, 34
miscellaneous works, 139
mixes, plaster, 30, 31
mosaics, ceramics, 31, 34
movable partitions, 43
multipoint heater, 106, 214

Natural soil, 175
nomogram, 82, 214
non-slip finishings, 10
nosings, 4, 10, 214

Oildraulic lifts, 102, 214
one-pipe system, 118, 214
opening gear, windows, 60
openwork grilles, 61

Painting: aluminium, 66, 211; chromates, 66, 212; colour, 64; drying, 65; finish, 66; knotting, 67; preparation, 64; primers, 66, 215; saponification, 65, 215; spread, 67; types, 65; undercoat, 66
partitions: finishing, 42; function, 215; dry, 43, 207; movable, 43; sliding, 40
pelmets, 36
personnel, 188
pitch: roof, 215; stairs, 5
pitch-fibre, 112, 215
plant schedule, 189
plasterboard, 29, 31
plastering: finishing, 25, 30; key, 30; materials, 24, 31; mixes, 31; renderings, 30, 181
plasticizers, 29, 215
plastics: handrails, 12; laminated, 43
plate, 139, 215
plumbing and sanitation: drainage, 109; joints, 129; materials, 129; piped supply, 128; sanitary ware, 119; systems, 118, 214, 216; traps, 130, 211, 215
polyurethene, *see* foamed plastics
polythene, 130
Portland cement, 24
powered hand tools, 169
programming: C.P.M., 193; progress charts, 192, 211
prefabrication, 208, 215
prestressed concrete, 204
project management, 185
public building, 4, 215
pumps, 165
P.V.C. tiles, 10, 34

Quarry tiles, 6, 107, 156
quicklime, 24

Rainwater: disposal, 131; gutters, 131; materials, 131; outlets, 131
ramps, 1, 150
rawlplugs, 57
records and progress, 190
reduce levels, 164, 194, 215
refrigeration, 99, 215
reinforcement, call-up, 14
renderings, bitumen, 181
retaining walls, 206, 215
research, 186
reveal, 146, 215
rising main, 128
roads: crossfall, 182, 212; drives, 154; soil-cement, 181

roofs: decking, 50; drainage, 131; pitch, 215; sawtooth, 206, 216; vapour barrier, 52, 216

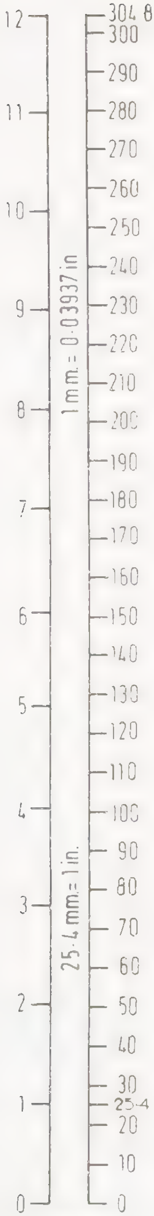
sand, 26
sanitary ware, 119
scaffolding, 148
scour, 144
self-powered tools, 165
services: conduits, 100; ducting, 95; food, 103; location, 100; special, 99; ventilation, 70
shapes of buildings, 198
shoring: dead, 142; raking, 139, 215
showers, 127
shutters and grilles, 61
single stack system, 118, 216
sinks, 190
site agent, 190
sodium lamps, 88
soil stabilization: bitumen, 181; blocks, 176; methods, 175; testing, 177
soil-cement: blocks, 179; foundations, 180; preparation, 179; roads and pavings, 181; site work, 182
soil stacks, 118, 214, 216
solar radiation, 82
sound insulation, 44
space structure, 199
staircases: balustrade, 12, 20; cast iron, 22; concrete, 13; fire, 5; formwork, 18; geometrical, 13, 213; going, 4, 213; nosings, 4; risers, 3, 13, 215; setting out, 3; spiral, 18; steel, 20; tread, 3, 216; types, 1; wood, 12
standardization, 208, 216
steel structures, 207
steps, precast, 14
storage, cupboard, 42
storey, 169, 216
sub-contractors, 189
sunblinds, 56
sun-dried block, 176
suspended ceilings, 51
system building, 206

Tall buildings, 208
tarmacadam drives, 156, 216
tell-tales, 148, 216
temperature movement, 209
terrazzo, 6, 34, 38
tiles: adhesive, 33; clay, 10; decorative, 32; floor, 34; glazed, 31; P.V.C. 34
timber framing, 44
time: charts, 192; painting, 65; saving, 207; speed of erection, 208
transportation, 166
training, 186
traps: bottle, 130, 211; sinks and bath, 130; w.c., 126, 215
tropicalizing, 100, 216
trusses and frames, 202

Undercoat, 66, 216
underpinning, 144
urinals, 128

Vapour barrier, 52, 216
variations, 190
Venetian blinds, 56
ventilation: air flow, 71; louvres, 71; mechanical, 76; natural, 70; roof extraction, 76; wall extraction, 77
veranda, 139, 176, 216

Wall: dwarf, 10, 212; linings, 43
wash basins, 128
water consumption, 129
wattle and daub, 176
water closet, bidet, 126, 216
welding plant, 170
wind bracing, 208
window openings, 60
wire, tying, 18, 211
wrot surface, 8, 216



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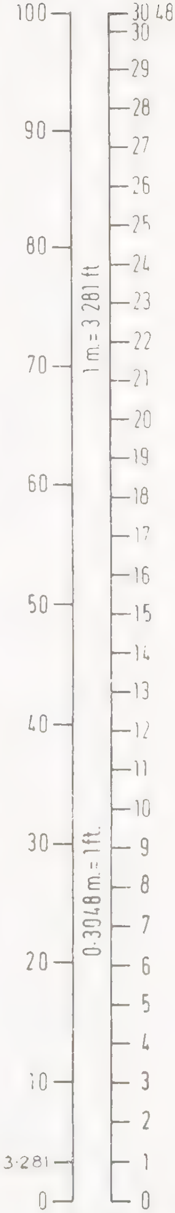

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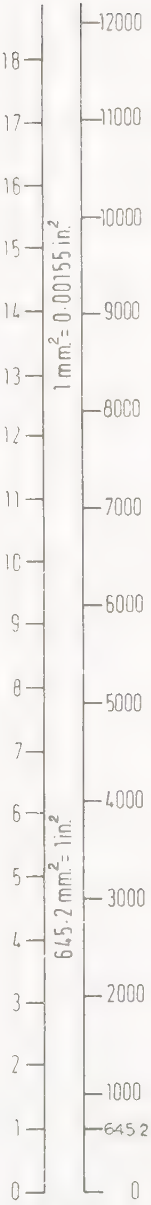

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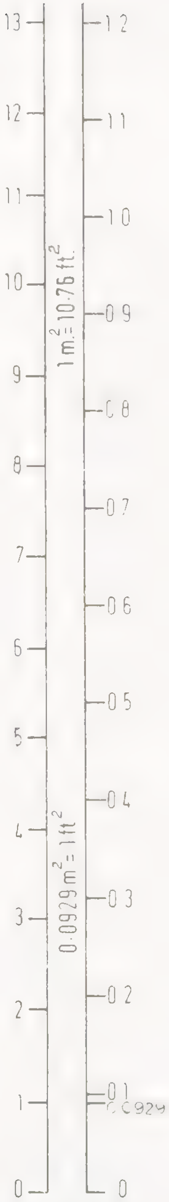

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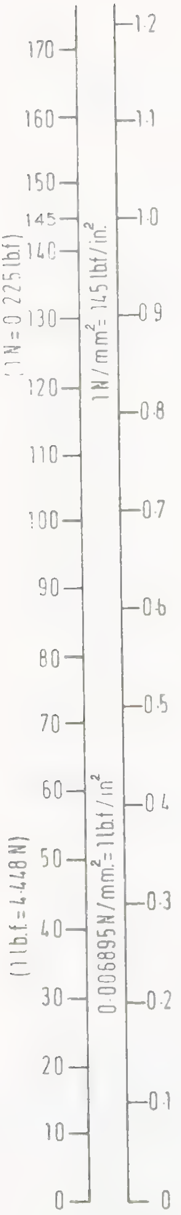

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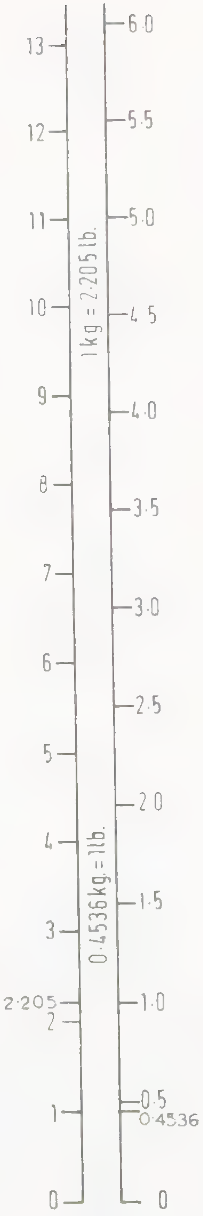

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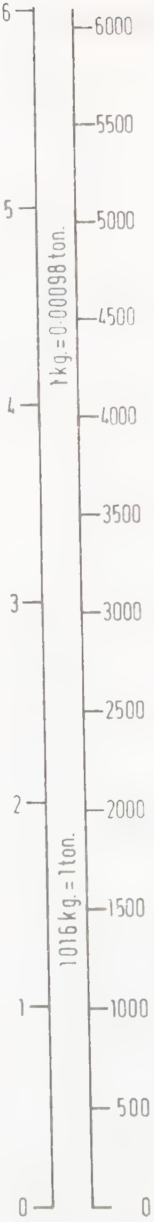

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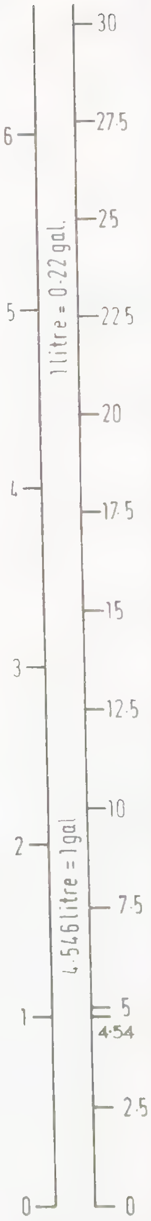

gal : litre

Volume 2 completes the Construction Technology Syllabus of the Ordinary Technician Diploma in Building and Civil Engineering, which meets the requirements of most tropical examining bodies, including the West African Examinations Council.

The volume deals with staircases, internal finishes, services, plumbing and sanitation, miscellaneous works, mechanical plant, soil stabilization and project management. (Foundations, walls, beams, columns, external coverings, floors, and roofs are considered in Volume 1.) In a final chapter the author deals with new materials and erection of structures. In this new edition all quantities have been coverted from the Imperial system of weights and measures to SI – the International System of units. Apart from updating the text many new and amended illustrations have been added, including some as answers to text questions.

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